PROLIQ® *The Liquid Stock Food*

PROPERTIES and APPLICATIONS

A Manual to assist in the use of PROLIQ on farms.

WJC 10/88

All information contained in this handbook is given in good faith after due and proper investigation, but no warranty of accuracy or reliability is given. The Lactose Company of New Zealand Limited accepts no responsibility or liability for the opinions and general information on the use of stock foods presented in this handbook.

TABLE OF CONTENTS

PAGE

CONTENTS

INTRODUCTION 1

GENERAL:

— Basic Information 2
— The Manufacturing Process 3
— Quality Control 3
— Storage 3
— Delivery 4

COMPOSITION:

— Physical & Chemical Properties 5
— Biological Value 5
— Mineral Value 7

USAGE & APPLICATIONS:

RUMINANTS

— Introduction 8
— Dietary Requirements 8
— Nutritive Value of PROLIQ 12
— Limitations to Use 14
— Performance Benefits — Dairy 15
— Performance Benefits — Beef 17
— Animal Health Considerations 20
— Feed Comparisons 21
— Feeding Recommendations 22
— Feeding Systems 27

PIGS

— Introduction 29
— Dietary Requirements 29
— Nutritive Value of PROLIQ 32
— Limitations to Use 34
— Performance Benefits 35
— Animal Health 36
— Feed Comparisons 36
— Feeding Recommendations 37
— Feeding Systems 39

CALVES

— Introduction 40
— Dietary Requirements 40
— Nutritive Value of PROLIQ 43
— Limitations to Use 44
— Performance Benefits 45
— Feeding Recommendations 45
— Feeding Systems 47

OTHER ANIMALS 47

REFERENCES 48

LIST OF ABBREVIATIONS 50

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WJC

Introduction

* PROLIQ is a liquid concentrate stockfood prepared from the mother liquor of lactose manufacture. The Lactose Company of New Zealand Limited has produced mother liquor for 42 years from its Kapuni factory in Taranaki, selling it into the regional stockfood market.

Mother liquor is a generic term applied to a liquid from which crystals have been extracted. In this case, the liquid started as whey and the crystals are pure milk sugar, or lactose.

PROLIQ is prepared from mother liquor by selecting the best mother liquor that falls within a stockfood specification and offering it for sale.

The objective of this handbook is to summarize the available published information and practical experience on the use of various stockfoods. This is then extrapolated to the use of PROLIQ on farms, to provide a ready reference for its efficient use.

* PROLIQ — registered trademark of the Lactose Company of New Zealand Ltd.

Section 1

GENERAL

1.1 Basic Information

Milk contains many valuable components which can be extracted or utilised to produce butter, cheese, sour cream, yoghurt, milk powders, casein, whey proteins and lactose. **(Table 1).**

Table 1

Major Components of Milk

Component	Concentration (% W/W)
Fat	3.8 - 6.2
Protein (Casein)	2.5 - 3.3
(Whey Proteins)	0.6 - 0.8
Lactose	4.6 - 5.2
Minerals (Ash)	0.7 - 0.8
Water	83.7 - 87.8

PROLIQ is the protein, energy and mineral rich by-product left after the removal of most of the lactose from whey. It has proportionally more protein and minerals than whey on a dry matter basis, resulting from the removal of crystallised lactose.

PROLIQ contains 6-9 times more solids, and 11-14 times more protein and minerals than whey on a liquid basis **(Table 2).**

Table 2

Major Components of Cheese Whey and PROLIQ

Component		Cheese Whey	**PROLIQ**
Total Solids	(%)	5.0 - 7.0	**42 - 45**
Protein	(%)	0.7 - 0.8	**9 - 11**
Carbohydrate	(%)	4.0 - 5.2	**17 - 19**
Minerals	(%)	0.5 - 0.7	**9 - 10**
Other Organic Solids	(%)	0.05	**7 - 9**
Water	(%)	93.0 - 95.0	**55 - 58**

1.2 The Manufacturing Process

Lactose is extracted primarily from cheese whey. A small proportion of lactic casein whey and permeates may be used at varying stages throughout the milk production season. Lactose crystals are produced after the whey is concentrated and crystalization is allowed to take place. The solid lactose crystals are recovered by centrifuging (spinning) with the liquid (mother liquor) separated and collected at the same time. The mother liquor is then pumped into the available storage tanks.

1.3 Quality Control

Mother liquor quality is measured against a general specification **(Table 3).** Samples are taken immediately after production, during storage and prior to delivery and measured for total solids, density, lactose, protein, minerals and viscosity. If material is outside the specification it may be blended at the storage stage or prior to delivery with other material to bring it inside the correct levels, or downgraded for alternative uses. Product within the specification is graded as PROLIQ, and sold as stockfood.

Table 3

General Specification for PROLIQ

Component	Unit	Range	Measurement Technique
Total Solids	%	42 - 45	Vacuum Oven
Protein	%	9 - 11	Kjeldahl (N × 6.3)
Lactose	%	17 - 19	Foss Milkoscan calibrated by Fehlings
Minerals (Ash)	%	9 - 10	600°C oven
Other Organic Solids	%	7 - 9	by balance
Density	kg/m^3	1100 - 1170	Weighing
Colour		< 4	Brew colour chart
Smell		no offensive odours	

1.4 Storage

A range of storage tanks are used at the Kapuni factory site. Their sizes range from 200,000 to 1,430,000 litres and are made from concrete or steel. The concrete tanks are coated with a polyurethane surface to protect against corrosion. This surface is renewed every 2-3 years to preserve the tank and the PROLIQ quality. The steel tanks have a glass surface fused to the steel to provide a permanent protection against corrosion.

Residence times for the PROLIQ in these tanks ranges from a few weeks to four months. Generally little deterioration of the PROLIQ occurs due to its high salt content.

1.5 Delivery

PROLIQ is blended from storage into smaller holding tanks. Articulated trucks (approximately 20,000 litre capacity) are filled from the holding tanks and are used to deliver PROLIQ directly to the customer. Each truck is fitted with pumps to discharge loads between 5,000 - 20,000 litres into the customer's storage facilities.

Section 2

COMPOSITION

2.1 Physical and Chemical Properties

PROLIQ is a slightly acid (pH 5.0-5.2), thick, yellow liquid. At a typical density of 1150 kg/m^3 (1.15g/ml), and 42-45% total solids, each 1000 litres contains 483-518 kg of dry matter (DM).

PROLIQ can appear to be thinner at various stages through a season. On investigation, total solids, protein, carbohydrate and mineral levels are normal. The apparent thinning is in part due to the changing nature of the milk proteins. These proteins (perhaps 3-4 in total) have a strong influence on viscosity and their proportions can change over the season. In addition, some fractionation occurs (breaking down of the protein into smaller groups of amino acids or peptides). This can reduce the viscosity but doesn't affect the nutritive value. It is like pre-digestion and could assist in speeding up digestion in the animal.

Physical separation of PROLIQ can occur under certain conditions. This phenomenon is typified by the appearance of a thin brown liquid (serum) on the surface or as layers within the PROLIQ. In effect, the protein fraction separates from the liquid fraction. Analysis shows that the total mineral content for the two fractions are very similar. However the brown liquid (serum) may be less palatable. Heat, contaminated storage tanks and age are known to contribute to this phenomenon. Remixing by pump or hand usually allows normal consumption to resume.

PROLIQ is corrosive to mild steel and uncoated concrete storage tanks over time. Timber, fibreglass, plastic and stainless steel are least affected.

2.2 Biological Value

PROLIQ is a milk derived product containing a large range of valuable biological components including essential amino acids, vitamins and carbohydrates.

Total carbohydrates range from 17-19% consisting mainly of lactose (15-16%) with other sugars accounting for 2-3%. Other organic solids total 7-9% and include lactic acid (mainly existing as calcium lactate which can account for 3-5%) and citric acid. Some fat left in the whey is also included accounting for 1-2% of the total.

The protein fraction (9-11%) contains a large range of amino acids in a very balanced composition for stock feed **(Table 4).** Digestible crude protein averages 210 g/kg DM. This measure also includes a range of water soluble vitamins **(Table 5).** The fat soluble vitamins (A, D, E, K) are virtually non-existant due to their removal with the milk fats in cheese manufacture.

Table 4

Amino Acid Composition of PROLIQ
(based on 42% total solids and 1150 kg/m³ density

Amino Acid	g/kg DM	g/l
Glutamic Acid	33.0	15.9
Aspartic Acid	19.2	9.3
Leucine	19.2	9.3
Lysine	15.6	7.5
Valine	11.8	5.7
Isoleucine	11.2	5.4
Threonine	11.2	5.4
Serine	10.1	4.9
Histidine	9.8	4.7
Alanine	9.0	4.3
Arginine	6.8	3.3
Phenylalanine	6.7	3.2
Tyrosine	5.5	2.7
Cystine	5.3	2.6
Methionine	5.0	2.4
Glycine	4.1	2.0
Tryptophan	2.8	1.4

Table 5

Vitamin Content of PROLIQ
(based on 42% total solids and 1150 kg/m³ density)

Vitamins	mg/kg DM	mg/l
Pantothenic Acid	60	29.0
Riboflavin (B2)	30	14.5
Niacin (Nicotinic Acid)	9	4.3
Thiamine (B1)	4	1.9
Biotin (H)	1	0.5
Cobalamine (B12)	0.1	0.05

Total metabolisable energy (ME) is 13 MJ/kg DM or 6.3 MJ/l. The high level of carbohydrates contribute the greatest proportion of this and is in a very easily available form for the animal to utilise. The lack of fibre means the other PROLIQ

components are also easily digestible releasing both energy and basic feed components to the animal rapidly when compared to fibre rich diets.

2.3 Mineral Value

PROLIQ contains a broad spectrum of minerals **(Table 6)**, accounting for 9-10% of the product. Nitrogen is measured in the protein fraction but is also included here.

PROLIQ is a rich source of potassium (K), nitrogen (N), chlorine (Cl), calcium (Ca), and sodium (Na). Significant amounts of other macro and micro elements are also included and these assist in making PROLIQ a well balanced feed. For mono-gastric and young pre-ruminant animals, the salt levels are high and care is required to limit their intake. For adult ruminants any excess salts are easily excreted without affecting performance.

Table 6

Elemental Analysis of PROLIQ
(based on 42% total solids and 1150 kg/m^3 density)

Macro Elements		g/kg DM	g/l
Potassium	(K)	43.0	20.8
Chlorine	(Cl)	32.0	15.5
Nitrogen	(N)	15.1	7.3
Calcium	(Ca)	15.0	7.2
Sodium	(Na)	14.0	6.8
Phosphorus	(P)	10.0	4.8
Sulphur	(S)	2.5	1.2
Magnesium	(Mg)	2.0	1.0
Micro Elements		**mg/kg DM**	**mg/l**
Iron	(Fe)	32.00	15.46
Zinc	(Zn)	14.00	6.76
Molybdenum	(Mo)	1.45	0.70
Copper	(Cu)	0.96	0.46
Boron	(B)	0.82	0.40
Manganese	(Mn)	0.40	0.19
Cobalt	(Co)	0.02	0.01
Selenium	(Se)	0.01	<0.01

Section 3

USAGE AND APPLICATIONS

3.1 Ruminants

3.1.1 Introduction

PROLIQ has been used mainly as a dairy supplement in Taranaki for 42 years. Initially treated as a cheap waste product to be disposed of, farmers readily used it. As more experience was gained PROLIQ's true value has become established and today it is recognised as a valuable stockfood concentrate.

The most efficient dairy users of PROLIQ fall into one of two categories. Firstly, if a herd is not producing up to its genetic potential due to under feeding at stages through lactation, PROLIQ is used to fill the shortfall. Secondly, where cow production is maximised on pasture alone and more production is required, cow numbers are increased and PROLIQ is fed to meet additional feed requirements.

Traditionally beef returns have been lower than dairy products and the purchase of feed supplements has not been a normal practice. In recent times the returns have improved, particularly for bull beef, thereby increasing the opportunities for improving performance with the strategic use of supplements. In summer/autumn pasture quality is low and often the quantity available is limited and, in winter, pasture growth is slow. During these two periods beef growth rates are limited when fed on pasture only system. Supplementation with PROLIQ during these times should increase weight gains to produce heavier animals in the same time scale, or decrease the time to reach target weights.

This section restricts itself to adult ruminants. Calves have a different digestive system and are discussed separately (section 3.3).

3.1.2 Dietary Requirements

The basic components of the diet are energy, protein, minerals, vitamins and water. Each of these will be discussed separately. A more detailed treatment can be found in the text "Milk Production from Pasture" by C. W. Holmes & G. F. Wilson 1984.

Energy is required for maintenance (essential body functions), growth (synthesis of new body tissue), pregnancy (maintenance and growth of the foetus)

and milk production. The amounts of energy required vary widely and are influenced by animal size, breed, stage of lactation, pregnancy, climate, feed sources and management stresses.

Typical annual energy requirements of a lactating cow show that higher producing cows require less energy to produce a unit (kg) of milk fat than lower producing cows **(Table 7).**

Table 7

Annual Energy requirements of a lactating cow producing at two levels of production (after Holmes et al 1984)

Assumptions	Liveweight at calving = 400 kg Energy content of milk containing 1 kg MF = 78 MJ Net energy	
Annual milk fat yield (kg)	200	150
Liveweight mobilised in early lactation (kg)	30	15
*ME Requirements (MJ)		
Maintenance	18,353	18,989
Liveweight gain	1,364	619
Pregnancy (35 kg calf)	1,600	1,600
Lactation	23,042	17,521
TOTAL	44,359	38,729
Energy required per unit milk fat (MJ/kg)	222	258

*ME = Metabolisable Energy

Energy requirements in New Zealand for raising beef **(Table 8)** are based on pasture diets and outdoor feeding. Some tables from overseas show lower requirements but these are for feedlot or loafing barn fed animals. Maintenance requirements for grazing animals can be up to 100% greater than housed animals.

Most tables are also based on steers and heifers. Bulls may differ in that they have higher maintenance requirements but lower requirements for liveweight gain. On balance the figures hold true.

Intake levels play an important role for weight gains. Friesian bulls will consume more than traditional beef breeds and steers/heifers. As feed quality and availability varies weight gains will be affected.

During a season it is important to match the feed intake (on an energy basis) with animal requirements. This will ensure adequate production and liveweight gain in the short and long term. Care must be taken that feed quality can supply the changing requirements, particularly at times when pasture quality may be low (eg. summer). At these times an animal may be physically full but there is insufficient energy in the feed to meet cow demands, resulting in a production drop.

A further consideration is the efficiency of ME utilisation. Liquid food sources with large proportions of soluble carbohydrates, low protein/energy ratios, and high ME concentrations, tend to have higher levels of ME utilisation. These foods require less time and muscular activity to digest and the energy is more efficiently utilised than other food sources.

Protein is required to meet the net requirements for protein in maintenance (replacing degraded tissue protein) or retained in the products of growth, pregnancy and milk synthesis. These requirements are met by ingesting sufficient nitrogen as protein and/or non protein nitrogen (NPN). Both dietary protein and NPN can be utilised by the rumen micro-organisms. Energy is required by the micro-organisms to utilise the protein and feedstuffs must have a minimum balance of protein/energy for it to be fully utilised.

Protein requirements for ruminants are summarized in **Table 9.** For lactation and pregnancy the protein requirements increase reaching a maximum of 1270 g/d for high producing cows in early lactation. Generally protein requirements are met on most pasture based diets or other foods containing over 10g protein/MJME.

Table 8

Metabolisable energy requirements for bull beef
(after Morris & MaRae 1984)

Live Weight (kg)

kg/day wt gain	100	150	200	250	300	350	400	450	500	550	600
0	22.6	28.3	33.1	37.4	41.4	45.0	48.5	51.7	54.8	57.7	60.6
0.10	24.2	30.4	35.7	40.5	44.9	48.9	52.5	56.0	59.5	62.9	66.0
0.20	26.0	32.5	38.3	43.6	48.5	52.8	56.7	60.5	64.4	68.1	71.7
0.30	27.7	34.8	41.0	46.8	52.1	56.9	60.9	65.0	69.3	73.5	77.5
0.40	29.6	37.1	43.9	50.1	55.9	61.0	65.3	69.7	74.4	79.0	83.5
0.50	31.4	39.5	46.7	53.5	59.8	65.2	69.8	74.4	79.6	84.6	89.5
0.60	33.3	41.9	49.7	56.9	63.8	69.6	74.4	79.3	84.9	90.4	95.7
0.70	35.3	44.4	52.7	60.4	67.8	74.0	79.0	84.3	90.4	96.3	102.1
0.80	37.4	47.0	55.8	64.0	72.0	78.5	83.8	89.4	95.9	102.3	108.6
0.90	39.4	49.6	58.9	67.7	76.2	83.1	88.7	94.6	101.6	108.5	115.2
1.00	41.6	52.3	62.1	71.5	80.5	87.9	93.7	99.9	107.4	114.7	122.0
1.10	43.8	55.0	65.4	75.4	84.9	92.7	98.8	105.3	113.3	121.1	128.9
1.20	46.0	57.8	68.8	79.3	89.4	97.6	104.0	110.9	119.3	127.7	135.9
1.30	48.3	60.7	72.3	83.3	94.0	102.6	109.2	116.5	125.5	134.4	143.1
1.40	50.7	63.6	75.8	87.4	98.7	107.7	114.6	122.3	131.8	141.2	150.4
1.50	53.1	66.6	79.4	91.6	103.4	112.9	120.1	128.1	138.2	148.1	157.9
1.75	—	—	—	—	—	—	133.9	144.3	154.4	164.6	175.0
2.00	—	—	—	—	—	—	—	—	171.7	182.5	193.3

Table 9

Net tissue protein requirements for maintenance and gain in dairy cattle (after Holmes et al 1984)

	Liveweight (kg)	Net Protein Requirement (g/TP/d) Daily weight gain (kg/d)			
		0.25	0.50	0.75	1.00
Milk fed heifer calves	25 - 80	50 - 72	86 - 110	120 - 146	152 - 180
Ruminant heifer calves	80 - 150	67 - 81	101 - 117	133 - 151	162 - 183
Heifers	150 - 350	75 - 97	104 - 131	133 - 163	159 - 192
Cows	350 - 500	92 - 102	120 - 131	147 - 160	173 - 186

Minerals are required for structural roles such as components of tissues and especially those of the skeleton. Rumen micro-organisms and body functions also require minerals. The amounts of dietary minerals absorbed, utilised, stored and excreted by animals are controlled by a number of homeostatic mechanisms. Therefore, average daily requirements are difficult to set. **Table 10** indicates the mineral concentration for the most commonly required macro and micro elements.

Table 10

Typical dietary concentrations of minerals for lactating dairy cows (after Ulyatt 1980)

Macro element		Required (g/kg DM)	Micro elements		Required (mg/kg DM)
Calcium	(Ca)	7.0	Iron	(Fe)	50
Phosphorus	(P)	3.5	Copper	(Cu)	10
Magnesium	(Mg)	2.0	Manganese	(Mn)	25
Sodium	(Na)	2.0	Zinc	(Zn)	26
Chlorine	(Cl)	1.2	Cobalt	(Co)	0.08
Potassium	(K)	6.0	Selenium	(Se)	0.05
Sulphur	(S)	2.5	Iodine	(I)	0.5
			Molybdenum	(Mo)	<0.5

Fast growing young stock and lactating cows have the highest mineral requirements. Under normal conditions magnesium and sodium in early lactation are the most important elements to be considered for possible supplementation on pasture fed animals. Reserves of calcium and phosphorous in the animal's body usually supply any short term deficiency. The onset of milk fever (hypocalcaemia) in high producing cows near calving is due to a failure in the homeostatic control of calcium in the animal rather than a simple mineral deficiency. Micro element deficiencies in pasture fed stock typically involve colbalt, copper, iodine and selenium.

Vitamins are essential for good health and production but are only required in small amounts. Vitamins A, D, and E are required from the diet while vitamins K and B are synthesised by the ruminal and intestinal bacteria. Vitamin B_{12} does require the presence of cobalt in the rumen to be produced.

Vitamin C is produced by the animal's body tissue. Pasture based diets usually supply all the animal's vitamin requirements. Calves on milk substitute diets may need vitamin A and D supplementation, and stock fed only root crops or forage crops may need vitamin D. Rations based on mature hays, straws, maize silage, root and cereal crops tend to be low in vitamin E.

Water is essential for a wide range of bodily functions including digestion, metabolism, waste removal and nutrient transfer. It is also the largest single constituent of the body (70-75% on a fat free basis). Requirements range from 3-6 litres/kg DM for dry stock to 5-10 litres/kg DM for lactating cows.

3.1.3 Nutritive value of PROLIQ

PROLIQ is a balanced liquid feed for adult ruminants supplying a rich supply of energy, protein, and minerals. When compared to other commonly used feed sources **(Table 11)**, PROLIQ has the equivalent energy content of meal, 10-62% more than pasture, 47-67% greater than silage and 34-78% more than hay, depending on their quality.

Table 11

Summary of nutrient composition of commonly used feeds for dairy cattle

FEEDSTUFF	Dry Matter (%)	Crude Protein (g/kgDM)	Metabolisable Energy (MJ/kgDM)	Mineral Concentration (g/kgDM)			
				Ca	P	Mg	Na
PROLIQ	**42**	**210**	**13.0**	**15.0**	**10.0**	**2.0**	**14.0**
GREENFEEDS							
Pasture Spring, leafy	14	240	11.8	6.0	4.5	1.5	1.5
Summer, leafy	20	150	10.0	8.5	4.0	2.0	2.0
dry & stalky	25	100	8.0	7.0	3.0	2.0	1.0
Winter, autumn saved	17	200	10.0	7.0	4.0	1.8	1.5
Maize 1.3 - 1.6 m	22	90	10.3	4.0	2.5	1.5	0.2
SILAGES							
Pasture good quality	23	200	10.0	7.0	4.3	1.7	1.7
poor quality	28	150	8.0	5.5	2.8	1.4	1.6
Maize	30	80	10.3	3.0	2.0	1.2	0.1
HAYS							
Pasture good quality	85	170	9.7	8.0	4.0	2.0	2.0
medium	85	110	8.5	6.0	3.5	1.9	1.7
poor	85	70	7.3	4.0	3.0	1.8	1.5
CONCENTRATE (Barley)	86	110	13.0	0.6	4.4	1.8	0.3

As a liquid feed with no fibre, and a large proportion of carbohydrate (sugars) the efficiency of energy use will be high. Rumen micro-organisms can readily access the energy to digest the protein in PROLIQ, or other constituents in the diet.

PROLIQ provides more crude protein (CP) than other common feedstuffs, except for leafy, spring grown pasture, and exists in an easily digested form. With an energy and protein balance similar to pasture, PROLIQ can be substituted into the diet at high levels, depending on the weight gains, stocking rates, costs of

alternative feeds and management set-ups. As a high source of energy and protein PROLIQ could be used as the primary source of food or to supplement low value feeds such as summer pasture, hay, silage, maize stubble or straws.

The lack of roughage in PROLIQ for rumen function means that this will still have to be supplied from another source. Where cheap, poor quality feeds are available PROLIQ could be used to provide the protein, energy and minerals, with the poor quality feed providing the roughage. This may also allow a higher dry matter intake of poor feeds, as consumption increases in response to a higher average energy content.

For instance, if beef cattle are fed poor quality hay or barley straw with various proportions of PROLIQ, liveweight gain potentials are increased from a base weight *loss* of 0.6 kg/day to a *gain* of 0.6 kg/day **(Table 12).**

PROLIQ provides an excess of most macro-elements required by ruminants. This is particularly important for sodium which occurs at low concentrations in some pasture species, greenfeed and silage maize and barley meals. Calcium may also be too low in leafy spring pasture, maize, poor quality hays and silages and barley meals. Adequate levels of sulphur and magnesium are provided in PROLIQ, however at certain stages of the year magnesium may be too low for a lactating cow's requirements, depending on the other dietary constituents.

In practical experience, only copper and magnesium have been required when blood analyses have been taken in cows fed on diets containing up to 35% PROLIQ as dry matter. Testing should always be undertaken to determine if trace elements are required as a delicate balance exists between deficiency and toxicity.

The excess salts (particularly K and Na) are easily excreted by the adult ruminant and can assist in maintaining soil fertility.

PROLIQ does not provide significant quantities of vitamins A, D or E for the cow. The vitamins in PROLIQ (B and K) would mainly act as a source of energy and/or nitrogen in the diet.

Table 12

Potential liveweight gains for beef cattle fed poor quality hay or barley straw supplemented with PROLIQ fed to appetite.

Assumptions: 300 kg liveweight, protein non-limiting, 32 MJ/kg liveweight loss, maintenance 41.4 MJ/day.				
Feedstuff	Metabolisable Energy (MJ ME/kg DM)	----- Intake - - - - Drymatter (kg/day)	Energy (MJ/day)	Liveweight Gain (kg/day)
Poor quality hay	7.5	4.0	30.0	-0.36
Barley straw	6.5	3.5	22.8	-0.58
Poor quality hay				
+ 20% PROLIQ	8.6	5.0	43.0	0.05
+ 50% PROLIQ	10.3	6.2	63.9	0.60
Barley straw				
+ 20% PROLIQ	7.8	4.4	34.3	0.22
+ 50% PROLIQ	9.8	5.8	56.8	0.42

3.1.4 Limitations to Use

Because PROLIQ is a well balanced feed, there are few theoretical limitations to use. Overseas research on whey, whey powders, concentrated whey and mother liquors can be extrapolated to the use of PROLIQ as their compositions are similar. Some adjustment must be made for the variations in total solids, protein and minerals.

Usually fibre is the primary source of energy for ruminants and the *sudden* introduction of large quantities of PROLIQ can cause digestive upsets. The lactose within PROLIQ is digested more readily than fibre and may result in excessive acid/gas production. To avoid these problems, PROLIQ should be introduced slowly and sufficient roughage included in the diet to stimulate rumen activity. This insures an adequate saliva flow to properly buffer rumen activity. If large quantities of PROLIQ are fed it would be better to feed poor quality hay, with high roughage content, in conjunction with PROLIQ. The PROLIQ provides a good source of protein and energy while the hay provides roughage. In experiments it has been shown that dietary fibre is more efficiently utilised when whey (or like products) is fed in conjunction with it.

To determine the correct rumen activity "chew time" is considered the best indicator by some overseas researchers. Ideally 35 minutes of chewing time/kg DM is proposed but 20-30 minutes is more realistic in practical terms. To meet these times the diet should not exceed 20% starch or 30% sugar if these times are to be met. A minimum of 2 kg of hay has been recommended to maintain rumen activity on whey fed dairy cattle. This is to have sufficient acetic acid production to support fat synthesis and milk production. Dry or beef stock have had this reduced to 1 kg.

Milk by-products have been used at levels up to 80% of the dry matter intake in closely controlled, feedlot systems. When PROLIQ is fed to dairy cattle a range of factors must be considered. Intake will be affected by the availability and quality of other feed, the size and shape of feeding troughs, time available for the animals to feed and variations in individual consumption. Cows have been known to consume up to 32 litres PROLIQ/cow/day and this would have accounted for the majority of their day's requirements. When considering long term consumption, the fibre requirements and the control over individual intakes an upper level of 50% of daily intake over a whole season for lactating cows is recommended (11.3 litres/cow/day). This equates to 5.5 kg DM/day and 71 MJ ME/day, approximately 50% and 62% of their daily dry matter and energy requirements respectively.

The major restriction to use at these levels is to have sufficient time for the animals to consume their daily requirements. Feeding systems would need to provide PROLIQ *ad lib* and be fed in close proximity to their other dietary components (normally pasture). Having PROLIQ available at all times also discourages gorging which might lead to over consumption of PROLIQ and too little roughage being ingested. Practical experience has shown that where cows have unlimited access to PROLIQ, they will consume small amounts frequently during the day, between feeds of pasture or other roughage. An ideal balance.

3.1.5 Performance Benefits — Dairy

A wide range of benefits have been assigned to PROLIQ by many farmers. These include:

- increased per cow production of milkfat
- increased per hectare production of milkfat
- increased liveweight gains
- improved animal health
- improved animal fertility
- improved pasture growth
- less wastage of additional feed

Most of these benefits can be related back to PROLIQ's balanced composition and its utilisation by the animal. PROLIQ compares more closely to pasture than any other common feedstuff. Hay, silage and maize have lower energy and protein levels and concentrates (e.g. barley meal) contain lower protein.

In addition, PROLIQ's low cost means that it can be used as a long term, permanent part of the productive cow's diet.

Few long term experiments have been conducted on the use of supplements and none on the use of PROLIQ. Results from a range of trials have shown that feeding supplements and the responses are very complex. Short term gains in milkfat production are varied and usually based on hay feeding or silage. The responses are typically in the range of 282-333 MJ ME/kg milkfat when supplements are fed at various stages over the year. These figures do not include any long term benefits from increased liveweights and other carry over effects. When these are included the adjusted efficiencies range from 160-241 MJ ME/kg milkfat **(Table 13).**

Table 13

Mean marginal efficiencies of milk fat production in feeding experiments using Jersey X Friesian cows.
(after Holmes *et al* 1984)

Stage of Lactation	Marginal Efficiency[1] (MJ ME/kg MF)	Adjusted Marginal[2] Efficiency (MJ ME/kg MF)
Pre-calving	—	241
Early Lactation	282	125
Mid to Late Lactation	333	160

[1] Short term [2]Long term

Extrapolating these results to the use of PROLIQ, it would require 38, 20 and 25 litres of PROLIQ to produce an extra kilogram of milkfat for pre-calving, early lactation and mid to late lactation, respectively (on long term efficiencies).

This relates very well to farmers' practical experience with PROLIQ where milk fat increases of 0.1-0.2 kg MF/cow/day are quoted. These farmers are typically feeding between 2-4 litres PROLIQ per cow per day over the milking

season giving a marginal efficiency of 20-40 litres PROLIQ/kg MF (126-252 MJ ME/kg MF).

When PROLIQ is fed without adjusting stock numbers, the amount of pasture left after grazing normally increases. If a farm has been chronically short of pasture and grazing levels very low, pasture regrowth is usually very slow. Introducing PROLIQ in these situations not only increases milk production but allows faster pasture regrowth because of the greater amount of leaf area remaining after grazing. The response to feeding PROLIQ in these circumstances comes from the improved dietary intake from PROLIQ and the extra pasture grown.

If grazing patterns are already at optimum levels for regrowth and meet cow demands then introducing PROLIQ may cause a long term decline in pasture production. This would be brought about because too much pasture is left after grazing (lax grazing) and annual pasture production and/or utilisation declines in these circumstances.

In general, the amount of additional pasture left after grazing is proportional to the amount of PROLIQ consumed. Stock numbers can be increased by the approximate % of the diet provided by PROLIQ. If 3 litres/cow/day is fed (1095 litres/cow/year), this equates to approximately 14% of the annual energy and 12% of the dry matter requirements. Cow numbers could be increased by this amount to convert the additional pasture to milk.

Responses are also complicated by the improved pasture growth brought about by the additional minerals returned to the paddocks by dung and urine. Cows being fed 3 litres/cow/day are returning large quantities of nutrients, particularly potassium. **(Table 14).**

Table 14

Estimated mineral excretions of animals fed 3 litres PROLIQ/cow/day, with 3 cows/hectare.

Mineral	Animal Requirment (g/kgDM)	**PROLIQ Content (g/kgDM)**	Excess (g/kgDM)	*Returned to Pasture (kg/ha/yr)
Ca	5.5	**15.0**	9.5	13.1
P	2.7	**10.0**	7.3	10.1
Mg	1.7	**2.0**	0.3	0.4
Na	1.5	**14.0**	12.5	17.3
Cl	1.0	**32.0**	31.0	42.8
K	4.5	**43.0**	38.5	53.1
S	2.0	**2.5**	0.5	0.7

*Based on 90% of excreted minerals returned to the pasture.

The high concentration of energy enables rapid liveweight gains. Heifers can be fed at high levels to boost mating weights and subsequent production. Well fed heifers can produce up to 10 kg MF more than one in poorer condition. PROLIQ enables both the cows and replacement stock to be reared on the same farm without competition for high value feed.

Animal health aspects are dealt with in section 3.1.7.

Improved animal fertility is most probably accounted for by better feeding levels achieved with the use of PROLIQ. Heifers 30-80 kg under target liveweights are typically only 80% mated after 4 weeks compared to 95% for heavier animals. Cows which are poorly fed after calving take longer to come into heat than well fed cows. Thin cows also take longer than well conditioned cows to come into heat and they also show lower conception rates.

As a supplement PROLIQ has very low wastage levels. Hay and silage can have losses of up to 50%, effectively doubling their cost. This increases PROLIQ's value when compared to other common feed sources for dairy cattle.

3.1.6 Performance Benefits — Beef

The lack of use for beef feeding has meant that the performance benefits are based on the interpretation of dietary requirements and the analyses of the feed components, although some interim trials have confirmed these predictions.

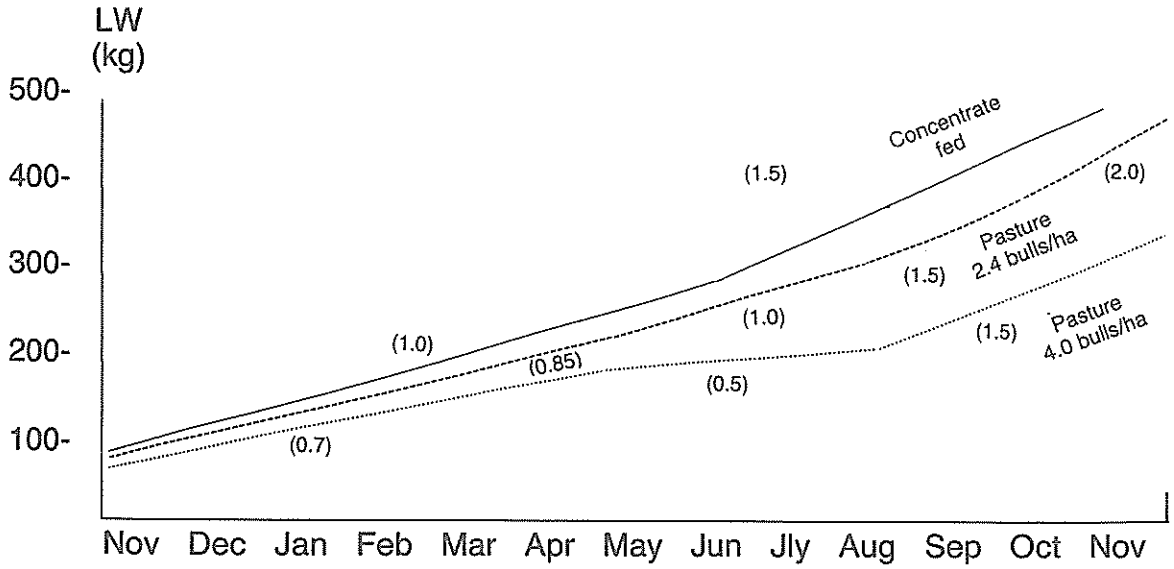
As a high protein and energy source PROLIQ is likely to be able to:

- increase total dry matter intakes
- increase liveweight gains for young animals (weaners-7 months)
- increase liveweight gains over winter
- increase stocking rates while maintaining liveweight gains
- enable the use of other cheap, poor quality feeds in conjunction with PROLIQ
- decrease times taken to reach target liveweight and increase turnover

Overseas work has shown that young stock fed on high quality feeds (concentrate) can average liveweight gains of 1 kg/day in their first year. This equates to liveweights of 350-360 kg at 12 months instead of 15-18 months for average pasture fed animals in New Zealand, or 13 months for a recently proposed bull beef system utilising pasture at low stocking rates (refer **Figure 1).**

Figure 1

Liveweight gains for pasture fed beef bulls at two stocking rates and compared to concentrate fed animals overseas ( ) kg/day



Typically, pasture fed animals have only averaged 0.6 kg/day in their first twelve months. Poor feed quality in summer (with occasional shortages) and slow winter pasture growth rates usually limit the growth rates. Recent work at Massey University has proposed that it is more economic to raise fewer, but larger, bulls. Budgeting pasture growth and animal intakes has shown that rapid growth rates are possible if high feed quality and quantity can be maintained.

High quality pastures (>10.5 MJ ME/kg day) can be ingested at rates ranging from 2-4% of the liveweight. Liquid products like PROLIQ allow much higher intake levels due to their rapid digestion. Lactating cows fed whey and pasture had intakes 0.7 - 1.0 kg DM/cow/day higher than cows fed pasture only (a 4-6% increase). Therefore diets incorporating various levels of PROLIQ should increase the potential growth rates by increasing both the dry matter and energy intakes **(Table 15).** Growth rates in excess of 1 kg/LW day for young bulls could be achieved if PROLIQ was used to supplement pasture throughout the season. In addition the use of PROLIQ and cheap low quality feeds (e.g. barley straw) in conjunction with pasture can provide sufficient energy to maintain growth rates in excess of 1.5 kg/LW day during winter for rising 1 year old bulls.

Table 15

Liveweight gains of beef bulls fed to appetite on pasture only compared to PROLIQ supplemented bulls (estimated) from weaning to 12 months age.

Assumption: 5% increase in total DM intake when PROLIQ incorporated in diet. 41.5 MJ ME/kg liveweight gain over 1.5 kg LW/day.

Period	Liveweight (kg)	Diet Pasture (%)	Diet PROLIQ (%)	Diet Straw (%)	Average Dietary Energy (MJ ME/kg DM)	Intake kg DM/day	Intake (MJ ME/day)	Liveweight Gains (kg LW/day)
Spring	100	100	—	—	11.5	3.4	39.4	0.90
		90	10	—	11.7	3.6	42.1	1.02
		80	20	—	11.8	3.6	42.5	1.04
		50	50	—	12.3	3.6	44.3	1.12
Summer	200	100	—	—	9.0	6.0	54.0	0.74
		90	10	—	9.4	6.3	59.2	0.91
		80	20	—	9.8	6.3	61.7	0.99
		50	50	—	11.0	6.3	69.3	1.21
Winter	300	100	—	—	10.5	9.8	103.9	1.50
		90	10	—	10.8	10.3	111.2	1.68
		80	20	—	11.0	10.3	113.3	1.73
		50	50	—	11.8	10.3	121.5	1.92
		30	50	20	11.0	10.3	113.3	1.73
		20	50	30	10.6	10.3	109.2	1.63

The use of PROLIQ to increase productivity could be approached in two ways:

1. To increase stocking rates.
2. To increase liveweight gains.

The choice of either (or both) of these is dependent on several factors including the cost of replacments, schedule prices, cartage, dressing out percentages, animal health costs, pasture growth rates and management.

Using a basic bull beef operation of buying 80 kg liveweight weaners, and selling for slaughter at 18 months of age, a comparison can be made between pasture only and pasture/PROLIQ combinations. At 4 bulls/ha on pasture alone, the addition of 8000 litres PROLIQ/ha can obtain the same liveweight gains but increase the stocking rate to 5.8 bulls/ha (45% increase). Alternatively, the same stocking rate could achieve higher growth rates to increase carcass weights by 66 kg/head (30% increase).

At 2.8 bulls/ha on pasture alone, the addition of 8000 litres PROLIQ/ha can increase the stocking rate to 4 bulls/ha (at the same liveweight gains) or increase both the stocking rate (to 3.26 bulls/ha) and the carcass weights by 90.1 kg/head **(Table 16).** If the bulls had the potential to achieve 750 kg liveweight (or greater) at 18 months then greater liveweight gains could be obtained with a compensatory drop in stocking rate.

The profitability of each operation must be evaluated as the greatest net carcass weight (slaughter carcass weight minus purchase carcass weight) does not always give the greatest profit. This example shows that the net carcass weights (in order from highest to lowest) are:

3.26 bulls/ha + PROLIQ, 5.8 bulls/ha + PROLIQ, 4.0 bulls/ha + PROLIQ, 4.0 bulls/ha pasture only, 2.8 bulls/ha pasture only.

However when purchase and PROLIQ costs, schedule prices etc. are taken into account, the net profit is (highest to lowest):

3.26 bulls/ha + PROLIQ, 4.0 bulls/ha + PROLIQ, 5.8 bulls/ha + PROLIQ, 2.8 bulls/ha pasture only, 4.0 bulls/ha pasture only.

Table 16

Effect of supplementing pasture with 8000 litres PROLIQ/hectare on bull beef stocking rates and liveweight gains

STOCKING RATE		(bulls/ha)	2.80	3.26	4.00	4.00	5.80
Energy Intake	Weaning-Slaughter	(MJ ME/bull)	39,730	49,521	27,978	39,730	27,978
	From Pasture	(%)	100	69	100	69	69
	From PROLIQ	(%)	0	31	0	31	31
Liveweights	Purchase	(kg/bull)	80	80	80	80	80
	Slaughter	(kg/bull)	559	*700	443	559	443
Liveweight Gain	Average	(kg/bull/day)	1.04	1.34	0.79	1.04	0.79
Dressing Out Percentage		(%)	51.5	54.0	50.0	51.5	50.0
Carcass Weight	Gross	(kg/bull)	288	378	222	288	222
	Gross	(kg/ha)	806.4	1232.3	888.0	1152.0	1287.6
	**Net	(kg/bull)	248	338	182	248	182
	Net	(kg/ha)	694.4	1101.9	728.0	992.0	1055.6

* Assumes bulls have potential to reach this weight
** Gross carcass weight minus purchase carcass weight (40 kg/bull)

3.1.7 Animal Health Considerations

Bloat is a common occurrence on many farms. Recent large scale surveys have found no positive evidence of any particular cause. Under rotational grazing systems, sudden access to large quantities of fresh herbage can lead to bloat. PROLIQ has been accredited with reducing pasture related bloat on some farms, but no trials have been conducted to verify this. The reduction in bloat was attributed to feeding PROLIQ prior to release onto a fresh pasture break. The cows were not as hungry and were less inclined to gorge themselves.

Bloating from excessive and rapid ingestion of PROLIQ has been noted by some farmers but is not common. It is probably caused by rapid fermentation of the sugars and subsequent gas production. Avoidance of situations which pre-dispose towards gorging is recommended. These include giving free access at all times so animals have a more relaxed feeding pattern and providing adequate feeding levels of all dietary components.

Milk fever (hypocalcaemia) is a common problem on dairy farms. The problem is related to the homeostatic control of calcium in the animal rather than a simple deficiency of the mineral. PROLIQ has a reasonable supply of calcium, and if fed 10-14 days before calving could decrease the mobilisation of bone calcium leading to lower plasma calcium. This could then precipitate the onset of milk fever. To reduce the incidence of milk fever the following steps are recommended.

(a) Keep cows in a moderate condition (score 5-6) prior to calving

(b) Normal intake and rumen function should be preserved at calving and the intake of feed maximised after calving.

(c) Attempt to feed a diet low in calcium prior to calving to stimulate hormone secretion with the release calcium from bones.

To assist this, PROLIQ should be withheld prior to calving and re-introduced slowly after calving. Where PROLIQ forms a large proportion of the dry cow's diet, some believe that more problems will occur if PROLIQ is suddenly stopped prior to calving. As a general rule, large, sudden dietary changes should be avoided.

Grass staggers (hypomagnesaemia) frequently occurs in early lactation where milk and maintenance demands are high. Diets high in potassium (e.g. pasture after potash application and PROLIQ) may predispose the onset of grass staggers in early lactation. As for pasture, PROLIQ fed animals should be supplemented with magnesium. If the majority of a herd are utilising PROLIQ it could be used as a carrier for the magnesium supplement.

Ketosis or acidosis (acetonaemia) is brought about by excessive mobilisation of body fat associated with the high energy requirements for milk production. It normally occurs ten days to six weeks after calving and is more prevalent in older cows. Prevention is better than cure as milk production may be lowered for a whole season after the onset of ketosis. The maintenance of uniformly high levels of feeding with good quality feed is preferred. High quality feeds such as PROLIQ are preferred as they contain more glucogenic precursors which counteract the problem.

3.1.8 Feed Comparisons

The dominant feed requirements for ruminants are protein and energy. In pasture fed animals energy is the most critical component due to high demands in early lactation and low energy contents in summer/autumn pastures and conserved pasture products (hay/silage). In addition, low pasture growth rates severely limit potential beef growth rates over winter.

Cost comparisons are complex due to the difficulty in assigning a monetary value to different benefits from feeds and the changing cost structures from season to season. If a comparison of providing a unit of energy (MJME) is used then a reasonably accurate picture can be achieved **(Table 17).**

PROLIQ provides energy at an equivalent cost to poor to average quality pasture. It provides energy at a fraction of the cost of other feeds; meal (30%), poor hay (45%), poor silage (50%), good hay (61%), good silage (63%). These figures do not take account of any utilisation adjustments. If utilisation of hay and silage are 30-50%, then PROLIQ is only 30-47% the cost of hay and 33-48% the cost of silage.

Table 17

Comparative costs of PROLIQ to other common feeds sources for dairy cattle assuming complete utilisation. (July 1988)

Feedstuff		Metabolisable Energy (MJME/kgDM)	Unit Cost (c/kgDM)	(c/MJME)
PROLIQ		**13.0**	***10-12**	**0.77-0.92**
PASTURE	Good	11.5	5-8	0.43-0.70
	Average	10.0	5-8	0.50-0.80
	Poor	8.0	5-8	0.63-1.00
HAY	Good	9.7	12-15	1.24-1.55
	Poor	7.3	12-15	1.64-2.12
SILAGE	Good	10.0	12-15	1.20-1.50
	Poor	8.0	12-15	1.50-1.88
BARLEY MEAL		13.0	35-38	2.69-2.92

*Cost range depicts different price categories for PROLIQ related to storage and consumption volume.

The high mineral levels can also be costed. If fertiliser rates can be reduced (Table 14) because of the excess minerals in PROLIQ then this reduces the basic cost. At 3 cows/hectare and 3 litres PROLIQ/cow/day the approximate equivalent to 200 kg/hectare of 50% potassic super-phosphate is added to the pasture. This effectively reduces the cost of PROLIQ so that the unit energy cost becomes 0.48-0.64c/MJ ME, equivalent to good quality pasture. It is important to note that these savings are only made when PROLIQ is fed in conjunction with pasture and fertiliser rates are reduced.

Over a whole season the relative costs of different feed sources can be calculated **(Table 18).** If no fertilizer benefit is considered, the use of up to 20% PROLIQ costs less to produce 200 kg milkfat than normal farming practices (ie. pasture plus hay and/or silage). The use of pasture only has been proposed but management is difficult. If the fertiliser value of PROLIQ is accounted for then the cost of production decreases and is cheaper than pasture only.

Table 18

Energy costs of feeding a cow producing 200 kg MF/year on different diets containing 44,359 MF ME

Assumptions: Cost c/MJ ME	Average quality pasture	0.65
	PROLIQ	0.85
	PROLIQ (Adjusted for fertiliser benefit)	0.56
	Hay (no wastage)	1.68
	Silage (no wastage)	1.54

Diet	Energy Cost		Energy Cost Adjusted for Fertiliser Benefits	
	$/yr	$/kg MF	$/yr	$/kg MF
Pasture	288.33	1.44		
Pasture + 5% PROLIQ	292.24	1.46		
Pasture + 10% PROLIQ	297.20	1.49		
Pasture + 20% PROLIQ	306.08	1.53	280.35	1.40
Pasture + 5% Hay	311.18	1.56		
Pasture + 10% Hay	334.02	1.67		
Pasture + 5% Silage	308.08	1.54		
Pasture + 10% Silage	327.81	1.64		

In reality most farmers would normally feed a combination of pasture, conserved pasture and PROLIQ. Adjustment to earlier calving dates, and maintenance of strict grazing regimes can allow the use of pasture and PROLIQ only with no hay or silage.

3.1.8 Feeding Recommendations

In general the following recommendations should be used:

1. Average PROLIQ consumption should be limited to 50% of the dry matter intake unless individual intake can be closely controlled.

2. At least 2 kg dry matter/cow/day as roughage must be supplied to maintain rumen activity and milk synthesis.

3. Introduce PROLIQ slowly over a period of 4-5 days to allow time for the rumen organisms to adjust. This applies after any period of non-use or when consumption is suddenly increased.

4. Provide sufficient time and space at feeding troughs to allow a relaxed consumption rate.

5. Do not feed 10-14 days prior to calving.

6. Supplement magnesium into the diet or drench during periods of danger from grass staggers.

7. Increase stock numbers to utilise extra feed made available, unless stock were underfed to begin with.

8. Maintain grazing rotations to maximise pasture growth and utilisation. Let PROLIQ consumption fill in any short term deficits.

9. Reduce fertilizer inputs in proportion to the amount of PROLIQ fed unless the farm is in a soil fertility improvement programme.

PROLIQ could be incorporated at up to 70% of the dry matter requirements in theory. This diet would have 30% sugar (as lactose) on a dry matter basis. When the balance of the diet is made up of a good source of roughage, the minimum chew time (25 minutes) is achieved, and rumen activity maintained.

However, in practice this would be difficult to control for individual animals within a herd. The variation in an individual animal's consumption would mean that some cows would over-consume and not take in sufficient roughage. Only by individually feeding cows (eg. feedlot or barn) could this control be maintained.

A practical upper limit of 50% of the dry matter intake as PROLIQ is recommended. This equates to about 4140 litres PROLIQ/cow/year (11.3 litres/cow/day) for an average sized cow. Current users are feeding up to 36% of the dry matter diet as PROLIQ (3000 litres/cow/year). N.B. 4140 litres would supply up to 65% of the cow's annual energy requirements.

Roughage to maintain rumen function and milk synthesis can come from several sources; pasture, hay, silage or straw. For lactating cows the requirement is critical as milk production can suffer. Heifers and dry, pregnant cows require less roughage (for rumen function only) so they can be fed larger proportions of PROLIQ.

When high proportions of PROLIQ are fed, poorer quality roughage sources may be better at providing adequate 'chew time' and rumen function. PROLIQ (70%) and grass silage (30%), only provides 18 minutes chew time per kg DM which is below the 25-30 minutes minimum. Long straw or hay provides 42 minutes at the same level of inclusion. In addition, the fibre in the poorer quality feeds is more efficiently utilised when fed in conjunction with the PROLIQ.

Rapid introduction of PROLIQ can lead to diarrhoea in extreme cases. If PROLIQ is introduced slowly the rumen organisms are able to adjust to the new energy source and few digestive upsets occur.

Practically, a slow introduction to PROLIQ can be achieved by diluting it with water at 1:4 - 1:5 and slowly increasing it to full strength after 4-5 days or limiting the volume made available each day. If introduced when there is ample pasture available (e.g. spring) cow consumption is held within reasonable bounds due to gut-fill from pasture.

Excessive consumption over short periods (gorging) can lead to problems e.g. bloat. Free access to PROLIQ reduces this problem as the animals have sufficient time to consume it at a relaxed pace. Adequate trough space and time to consume are important (see section 3.1.9). Feeding in the paddock also reduces the problem.

By not feeding 10-14 days prior to calving, PROLIQ will not interfere with the animal's homeostatic control of calcium. Withholding PROLIQ until after calving

will allow calcium release from the bones by reducing the concentration of calcium in the diet.

Addition of magnesium to PROLIQ may help balance the Mg/K ratio in the diet, but current trends call for the total magnesium requirements to be supplied as a daily drench, regardless of dietary intakes.

Stock numbers should be increased when additional pasture is made available from the feeding of PROLIQ. This will enable the additional pasture made available to be converted into extra production. If this pasture is not utilised it can lead to a reduction in average pasture growth rates. It is normally inefficient to conserve the extra pasture as hay or silage. As a guide, the stock numbers should be increased by approximately the same percentage as PROLIQ is of the total dry matter intake. If the stock were underfed to begin with, then the figure should be lowered.

PROLIQ should be used as a buffer against short-term feed deficits. When maintaining rotation lengths to maximise pasture growth or conserving pasture (hay, silage or autumn saved pasture) there may be times when there is insufficient pasture in a paddock for a normal daily grazing. Additional paddock area should not be provided. The additional feed needed should be provided by the PROLIQ. In this way, both pasture and PROLIQ utilisation are maximised. One approach to this can be illustrated by an energy balance **(Table 19).** A balance of cow energy requirements (protein and minerals assumed to be non-limiting) and that able to be supplied by the pasture can be calculated. Any deficit between what is required by the cow and what is available as pasture, can be supplied by PROLIQ. From the example shown it can be seen that without conserving pasture the range of values for PROLIQ in the diet is 0-87% of the dry matter while the average consumption is only 36%. By feeding higher proportions of the diet as PROLIQ between October-February, the opportunity to conserve feed exists **(Table 20).** In addition, feeding more PROLIQ in April-June means autumn pasture can be saved (+ energy balance) to use in late winter and early spring (especially prior to calving when PROLIQ should be withheld).

This approach ensures that a balanced diet is maintained for the herd with a maximum of 50% of the diet as PROLIQ and any seasonal variations can be accounted for.

Table 19:

Energy and feed balance utilising pasture and PROLIQ with no pasture conservation.

MONTH	PERIOD	COW (kg)	YIELD kg MF	ENERGY REQUIREMENTS MJ/Cow/day	PASTURE PRODUCTION kg DM/ha/d	kg DM/farm /period	MJ/kg /DM	MJ/farm/ period	REQUIREMENTS MJ/herd/ period	PROLIQ MJ/ period	l/cow/d	% of DM Intake
JULY	1	422	0	66	4	3136	11.0	34496	184800	150304	8.5	79
AUG	2	380	18	136	5	3920	11.0	43120	380800	337680	19.1	87
SEPT	3	378	19	140	18	14112	11.0	155232	392000	236788	13.4	56
SEPT-OCT	4	381	19	157	28	21952	11.3	248058	439600	191542	10.9	40
OCT-NOV	5	389	18	154	48	37632	11.5	432768	431200	0	0.0	0
NOV-DEC	6	397	17	147	42	32928	11.3	372086	411600	39514	2.2	8
DEC-JAN	7	405	16	140	41	32144	10.3	331083	392000	60917	3.5	13
JAN-FEB	8	406	13	107	35	27440	9.2	252448	299600	47152	2.7	12
FEB-MAR	9	400	12	102	21	16464	9.5	156408	285600	129192	7.3	38
MAR-APR	10	397	11	100	22	17248	10.0	172480	280000	107520	6.1	32
APR-MAY	11	397	8	98	23	18032	10.0	180320	274400	94080	5.3	29
MAY-JUN	12	398	0	44	13	10192	10.5	107016	123200	16184	0.9	11
JUN-JULY	13	405	0	56	5	3920	10.5	41160	156800	115640	6.6	69
TOTAL			151	40516		239120		2526675	4051600	1526493		
AVERAGE		397			23		11.0				7.0	36

ASSUMPTIONS

Herd Size: 100

Farm Size: 28 ha

Production: 150 kg MF/cow/yr

Table 20:

Energy and feed balance utilising pasture, and conserved pasture

MONTH	PERIOD	COW kg	YIELD kg/MF	ENERGY MJ/cow/d	PASTURE PRODUCTION kg DM/ha/d	kg/DM/farm /period	MJ/kg /DM	MJ/farm/ period	PROLIQ l/cow/d	MJ/period	SUPPLEMENTS kgDM	MJ/period	REQMTS MJ/herd/ period	BALANCE MJ/period	PROLIQ % of DM intake
JULY	1	422	0	66	4	3136	11.0	34496	5	88200	8235	70000	184800	7896	37
AUG	2	380	18	136	5	3920	11.0	43120	12	211680	12941	11000	380800	-16000	49
SEPT	3	378	19	140	18	14112	11.0	155232	11	194040	0	0	392000	-42728	51
SEPT-OCT	4	381	19	157	28	21952	11.3	248058	10	176400	0	0	439600	-15142	38
OCT-NOV	5	389	18	154	48	37632	11.5	432768	10	176400	0	0	431200	177968	26
NOV-DEC	6	397	17	147	42	32928	11.3	372086	6	105840	0	0	411600	66326	20
DEC-JAN	7	405	16	140	41	32144	10.3	331083	3	52920	0	0	392000	-7997	11
JAN-FEB	8	406	13	107	35	27440	9.2	252448	3	52920	0	0	299600	5768	13
FEB-MAR	9	400	12	102	21	16464	9.5	156408	7	123480	0	0	285600	-5712	37
MAR-APR	10	397	11	100	22	17248	10.0	172480	7	123480	0	0	280000	15960	35
APR-MAY	11	397	8	98	23	18032	10.0	180320	6	105840	0	0	274400	11760	31
MAY-JUN	12	398	0	44	13	10192	10.5	107016	6	105840	0	0	123200	89656	44
JUN-JLY	13	405	0	56	5	3920	10.5	41160	4	70560	2353	20000	156800	-25080	46
TOTAL			151	40516		239120		2526675			23529	*200000	4051600	*262675	
AVERAGE		397			23		11		7						34

ASSUMPTIONS

Herd Size: 100
Farm Size: 28 ha
Supplement: 9 MJ/kg DM
*Only 75% of the pasture value is retained in the supplement.

It may be possible to feed higher levels of PROLIQ to beef cattle but a limit of 50% of the intake as PROLIQ should be adopted first. Any increases upwards should then be taken gradually monitoring animal health and performance.

Some overseas feed lot systems utilising whey have found that a few beef animals are more difficult to initiate into feeding. These animals are usually culled. Dairy breeds (e.g. Friesian) are easier to adapt to PROLIQ than beef breeds. It is likely that this is related to the early feeding management of dairy compared to beef animals.

If calves are purchased who have had PROLIQ incorporated in their early diet, then few feeding problems will be noted.

The choice of a beef policy is complex involving decisions on when to purchase and sell, target liveweights and seasonal pasture growth patterns. Whichever system is decided on, a feed budget should be utilised to predict how much PROLIQ is needed in total and how to manipulate the available pasture and PROLIQ to ensure a correct balance in the diet **(Table 20).**

Lastly, fertiliser inputs can be reduced when using PROLIQ. At 3 litres/cow/day average, about 200 kg/hectare of 50% potassic super phosphate can be saved. Soil and plant analyses should be used to assist in any decision to cut back fertiliser.

3.1.9 Feeding Systems

The feeding system used on a farm must take into account several important functions:—

- financial constraints
- storage requirements
- feeding troughs/stations
- introduction of PROLIQ to stock
- integration with the utilisation of other feed sources

A range of storage options are available to the farmer. Storage containers must be of sufficient size to take the minimum delivery volume. Ideally a storage capacity 25% greater than the minimum delivery allows sufficient spare volume to feed stock around delivery delays or when orders not placed in time. The storage must be easily accessible for the delivery trucks or have piped inlets which allow trucks to discharge from the tanker track or equivalent. 80 mm (3 inch) BSP screw or Kamloc fittings are required.

Stainless steel or plastic (including fibreglass) construction provide the best long term storage as it resists corrosion by the PROLIQ. Concrete tanks are suitable and their life can be extended with regular cleaning and coating with a polyurethane sealant. Mild steel is adequate although, in the long term, they will rust. Commercial coatings (e.g. gel coat) can significantly increase the life of the mild steel.

The feeding troughs must be easily accessible by stock. Normally farmers use low cheese vats adjacent to the yards where stock can consume PROLIQ prior to and/or after milking. Where large volumes are fed, paddock feeding allows more time for consumption. The amount of trough space is dependent on the volume of

PROLIQ to be consumed/cow and how long she will normally have to consume it. 0.5 to 0.6 metres of space per animal is required, however usually no more than 15-20 animals will drink at a time due to social ordering. The trough should not exceed 0.7 m in height. Where consumption needs to be restricted this system may require a set volume to be offered per day so this requires separate storage and feeding containers. If narrow troughs are used a wooden board can be floated on the surface to limit intake by allowing licking only, rather than drinking. If paddock feeding is considered, a portable tank and separate trough are useful. Pasture damage can occur around a trough. These areas are generally small and hard fill or permanent feed pads adjacent to several paddocks would be useful.

Feeding troughs can be constructed from the same materials as the storage containers. Timber is also useful in troughs as a smaller, narrow profile is required.

The introduction of PROLIQ to animals offers an interesting challenge. PROLIQ is an acquired taste but after it has been eaten once, there are few problems with re-introduction. A few practical tips are as follows: (N.B. All of these are not suited to all classes of stock).

1. Feed PROLIQ to calves (refer section 3.3). As adults they will readily begin consumption.

2. Offer to hungry animals. As the demand for feed increases, more cows will begin to consume PROLIQ.

3. Pour PROLIQ over other feed e.g. hay or silage. The animals will consume both and acquire a 'taste' for PROLIQ.

4. Pour PROLIQ over the animals' backs/sides. As a sticky substance PROLIQ will be licked by the animals, particularly if they are used to flank painting.

5. Drench cows with PROLIQ in the yard.

6. Pour PROLIQ into a trough then put a layer of meal (100 mm or so) on the top. As the meal is consumed it is slowly mixed with the PROLIQ until it is consumed on its own.

7. Feed PROLIQ in the paddock to allow more time for sampling.

PROLIQ will normally be fed in conjunction with pasture, hay and/or silage. To achieve the required balance sufficient time must be allowed to consume the various feeds. At low levels of inclusion, PROLIQ is easily consumed by allowing access before and after milking (up to 10% of their dry matter requirements). When higher levels are required paddock feeding or the use of feed pads close to the paddocks are necessary. This minimises gorging by animals and also saves animals from walking to and from the shed to get their day's PROLIQ requirements. The consumption of small amounts of PROLIQ frequently during the day, interspersed by pasture or other roughage is considered the best way to balance the diet. PROLIQ feeding could be used with conventional grazing systems like On/Off methods. In this technique PROLIQ could be used while the stock were not grazing.

During winter, some farms with feed lots, loafing pads or wintering barns could readily use a diet of PROLIQ and hay or silage. Limited access to pasture could be used when soil conditions allowed grazing. This system would be most suited to heifers and dry pregnant cows with low daily requirements compared to lactating cows, and would allow the conservation of high quality spring pasture for the lactating cows. In addition, poor quality hays or straws could be used in conjunction with PROLIQ as only the roughage component is necessary to maintain rumen function. This may allow cost savings and much higher stocking rates.

3.2 Pigs

3.2.1 Introduction

Approximately 70% of the cost in raising pigs is associated with feed. Farmers are continuously looking for cheap food sources which can maximise their profitability. PROLIQ provides a cheap source of protein and energy with the advantages of liquid feeding, longevity in storage, and year round availability.

Dietary formulations for pigs are very complex and should always be undertaken with care. The general concepts discussed in this section should be used as a guide only.

3.2.2 Dietary Requirements

Energy, protein, vitamins, minerals and water are the basic dietary components for pigs. Energy and protein are usually the most costly to supply.

Each major class of pig has differing dietary requirements **(Table 21).** This explains the need to formulate diets for each class in order to maximise productivity. The palatability and digestibility of the diet is also very important, particularly for weaners.

Table 21

Basic dietary requirements of pigs (after Stables 1985)

Class	Suckers	Weaners (4-10 wks)	Growers (Restricted)	Growers (Ad Lib)	(Sows)
Minimum crude protein (%)					14.0
Minimum digestible energy (MJ/kg DM)	13.0	12.8	12.7	12.7	12.6
Lysine: energy ratio (g/MJ DE)	0.9	0.85	0.65	0.75	0.5
Calcium (%)	1.0	1.0	1.0	1.0	1.0

Energy costs more in total than any other dietary component. It is provided by carbohydrates (starches and sugars) and by fats or oils of the feed. It some cases protein can be utilised for energy when there is an imbalance in the diet compared to the pigs' requirements.

Starches and sugars are generally well utilized by the pig. The presence of fibre in the diet reduces the overall digestibility of energy by protecting potentially digestible material from breakdown. The energy concentration in most diets ranges from 12-14 MJ DE/kg. With sources of high bulk and low energy more feed needs to be ingested to meet the required energy levels. In extreme cases gut fill could limit intake and energy requirements may not be met.

In general, the energy intake is split between maintenance (35%), liveweight gain (40%), and the processes which drive protein and fat deposition (25%).

Protein in the pig's diet is converted into meat and can come from a variety of sources; vegetable, fish, by-products, wastes. When proteins are ingested, protease enzymes in the digestive system break them down into their component amino acids. The amino acids are then absorbed into the bloodstream from the small intestine of the alimentary tract. The amino acids are required for muscle and hair tissue so they are essential for growth.

The liver synthesises amino acids from the absorbed amino acids, or from nitrogen. However, there are eleven amino acids which must be supplied in the diet and are termed essential. Lysine, methionine, cystine, threonine and tryptophan are given prominence when formulating pig diets as conventional feed ingredients are relatively deficient in one or more of these. The balance between these is also very important.

When a diet is low in one amino acid, production will be limited to the level sustainable by that amino acid, regardless of the amount of the others. For barley based diets this is generally lysine.

Minerals are used in many body functions as well as being integral parts of tissue structure. 22 minerals are believed to be essential for pigs; seven macro nutrients, eight micro nutrients, and seven 'newer' trace elements where essentiality is based on growth effects with animals in highly specialised conditions. Only the 15 macro and micro nutrients are mentioned from now onwards.

In general only calcium, phosphorus, sodium and chlorine are considered carefully in diets as most feeds have adequate amounts of the other macro nutrients **(Table 22).**

Table 22

Typical concentrations of essential mineral elements in the pigs diet (after Hart 1982)

Macro Nutrients		(%)	Micro Nutrients		(mg/kg)
Calcium	(Ca)	1.50	Iron	(Fe)	50
Phosphorus	(P)	1.00	Zinc	(Zn)	30
Potassium	(K)	0.20	Copper	(Cu)	3
Sodium	(Na)	0.16	Manganese	(Mn)	0.5
Chlorine	(Cl)	0.11	Iodine	(I)	0.5
Sulphur	(S)	0.15	Cobalt	(Co)	0.05
Magnesium	(Mg)	0.04	Molybdenum	(Mo)	2
			Selenium	(Se)	2

Both the Ca and P levels and balance in the diet are critical. A ratio of approximately 1.3:1 (Ca/P) is considered optimum. An imbalance may be as harmful as a deficiency of the element in the diet. P in vegetable diets is also poorly available. Na and Cl are usually added to the diet with salt. This also acts as an appetiser which is particularly important in the creep ration. Salt toxicity may occur when the diet contains 1-2% salt, particularly where pigs are on a restricted water supply.

Micro nutrients vary according to the raw materials in the diet. Proprietary mixes are usually supplied and added to meal or directly into liquid feeds.

Approximately 14 **vitamins** or vitamin like substances are required in the pig's diet **(Table 23).** They are only required in small amounts but perform essential bodily functions. Increased pressures from high productivity, management changes and a reduced range of feed ingredients have increased the dietary requirements for vitamins.

Table 23

Recommended vitamin levels for growing pigs (after Gibbs 1982)

Vitamin	Unit	Level (units/kg DM)
A	IU	10,000
D	IU	1,200
E	IU	50
K3	mg	1
B1	mg	2.5
B2	mg	5
B6	mg	5
B12	mg	0.03
C	mg	100
Nicotinic acid	mg	20
Pantothenic acid	mg	15
Folic acid	mg	0.5
Biotin (Vitamin H)	mg	0.15
Choline	mg	1,000

Overdosing is unlikely to occur with vitamins except for Vitamins A and D in practical feeding situations.

Water is considered the most important dietary component and free access to fresh clean water at all times is advocated for all classes of pigs. Water is lost from the body from the lungs, skin, intestines (faeces) and kidneys (urine). Its replacement is critical, and water is required to form part of new tissue formation (growth).

Water loss through the kidneys increases as higher levels of dietary protein are fed. Large intakes of salts will increase urine output and increase water demand also.

3.2.3 Nutritive Value of PROLIQ

PROLIQ is a good source of cheap protein and energy for the growing pig. It also provides B group vitamins and minerals but these are considered of lesser importance. The high salt and lactose level in PROLIQ means that it has an upper limit of inclusion in the diet of about 30%, depending on the desired growth rates.

At 13 MJ/kg DM as metabolisable energy, PROLIQ provides a readily available form of energy. In liquid form (6.3 MJ/litre, or 5.5 MJ/kg fluid) PROLIQ could be considered a bulky feed, however its high level of protein (9-11%) places it out of this area **(Table 24).** On a dry matter basis PROLIQ provides the equivalent energy to most meal mixes for all classes of pig except perhaps for piglets. The lack of fibre and its liquid form means that energy conversion levels are high.

Table 24

Comparison of PROLIQ to some commonly used bulky feeds for pigs on a fresh (wet) basis

Feed	Dry Matter (%)	Crude Fibre (%)	Digestible Energy (MJ/kg fresh weight)	Digestible Crude Protein (%)
PROLIQ	**42.0**	**0.0**	**5.5**	**10.0**
Swill (garbage) cooked	27.0	1.5	3.5	2.5
Grass (Fresh)	20.0	4.0	3.0	2.6
Brewers grains (fresh)	32.0	6.1	2.5	5.5
Potatoes	20.0	0.4	2.3	0.5
Fodder Beet	22.0	1.3	2.0	0.7
Carrots	13.0	1.3	1.8	0.8
Swedes	12.0	1.2	1.7	0.9
Whey	6.0	0.0	0.9	0.8

The major energy source is lactose and this can cause intake limitations in adult pigs. Young pigs have a high lactase activity in the intestine to utilise lactose. Pigs up to 5 weeks of age can tolerate up to 57% lactose in the diet. After weaning, as more complex carbohydrates are introduced into the ration (e.g. starch) lactase activity decreases. At liveweights above 25 kg, only 15-20% lactose can be fed before weight gains are reduced. However, some work has shown that intestinal flora of pigs fed on high lactose diets continuously from an early age have a higher lactase activity than pigs on a lactose free diet. Therefore, if lactose is to be effectively utilized, adaption of the intestinal flora to lactose is essential. This usually takes a few days after introduction.

Proteins in PROLIQ are readily digested and have an amino acid balance which is in good agreement with an ideal formulation (refer **Table 25).** In addition to the correct balance, PROLIQ provides significant quantities of the more important amino acids **(Table 26).**

Table 25

Comparison of amino acid balances in PROLIQ compared to ideal levels (after Smith et al 1985)

Amino Acid	Ideal Ratio	**PROLIQ ratio**
Lysine	100	**100**
Methionine & Cystine	54	**68**
Tryptophan	13	**18**
Histidine	34	**63**
Phenylalanine & Tyrosine	101	**78**
Threonine	59	**72**
Leucine	89	**123**
Isoleucine	46	**72**
Valine	66	**76**

Table 26

The balance of some essential amino acids recommended for growing pigs compared to different feedstuffs

Feedstuff	Amino Acid (% of crude protein)		
	Lysine	Isoleucine	Tryptophan
Ideal Balance	7.0	3.8	1.0
Barley	3.5	3.4	1.8
Maize	2.5	3.8	1.0
Meat & Bone Meal	4.4	2.6	0.4
Dried Blood	8.2	0.8	1.3
Fish Meal	9.6	5.0	1.8
Mixed Meal*	5.5	2.8	1.5
PROLIQ	**7.4**	**5.3**	**1.3**

* Barley (82.5%), Meat & Bone Meal (12.5%), Dried Blood (5%).

The protein/energy balance of PROLIQ is very good due to its high protein levels. It provides levels slightly higher than recommended levels **(Table 27)** so it could be used to balance feeds with lower protein levels e.g. bread, garbage, cereals.

Table 27

The ratio of some essential amino acids to energy in commonly used feed ingredients (after Stables)

Feedstuff	Amino Acid/Energy Ration (g/MJ DE) Lysine	Isoleucine	Tryptophan
Ideal Balance	0.84	0.46	0.12
Barley	0.27	0.27	0.14
Maize	0.14	0.21	0.05
Garbage*	0.50	—	—
Bread	0.13	—	—
Meat & Bone Meal	1.76	1.04	0.15
Dried Blood	6.20	0.57	0.97
Fish Meal	3.80	2.80	0.70
Skim Milk Powder	1.78	1.21	0.29
Wholemilk	1.02	0.60	0.19
PROLIQ	**1.20**	**0.86**	**0.22**

* Assuming about 25% fat (dry matter)

PROLIQ provides an ideal balance of calcium/phosphorus of 1.5/1 and in sufficient quantities (1.5% Ca, 1.0% P on a dry matter basis). Excessive amounts of sodium, chlorine, potassium and magnesium are present. The pig must have free access to water to assist its kidneys to expel these in the urine and reduce the chances of salt toxicity occuring.

Micro nutrients are not supplied in sufficient quantities to meet requirements. These need to be supplemented into the diet as PROLIQ only provides between 12-60% of the amounts needed (on a dry matter basis).

B group vitamins (B1, B2, B12, nicotinic acid, pantothenic acid, biotin) occur in large amounts, at concentrations of 1.5 to 6.5 times of the requirements. The exception is nicotinic acid (niacin) which is at ½ the required levels. Fat soluble vitamins (A, D, E, K) and vitamin C need to be added to the diet as these are absent from PROLIQ.

3.2.4 Limitations to Use

Salt and lactose content are the two major limitations to the use of PROLIQ in the pig's diet.

The relatively high salt content (sodium and potassium) in PROLIQ means that scouring can occur at high levels of inclusion, or salt poisoning in extreme cases. The salts also affect milk production in lactating sows. The piglets can have an increased level of scouring and increased mortality. PROLIQ feeding is not recommended for lactating sows. Ample supplies of good quality, ad lib water must accompany the PROLIQ diet to avoid toxicity and scouring problems to the other pigs.

Lactose can be utilized effectively by the young pig, but this ability usually decreases with age. Decreased appetite, liveweight gain and scouring can occur

at high rates of inclusion. Generally liveweight gains suffer above 30% lactose in the diet (on a dry matter basis).

The use of PROLIQ does require a liquid (slurry) feeding system, tanks and troughs. This may be a limitation for some piggeries. Corrosion of these systems (particularly metal and concrete) can occur.

In general, PROLIQ is limited to 25-30% of the diet on a dry matter basis. This equates to a lactose level of 10-12% (of the dry matter) when mixed at these rates. Salt levels also decrease with the total minerals value down to 2.3-3%. At this upper limit of inclusion PROLIQ compares favourably with other limits placed on dietary supplements **(Table 28).**

Table 28

Limits to inclusion in diets of various feedstuffs (after Smith 1982)

Feedstuff	Upper Limit (% diet)	Reason for Limit
PROLIQ	**25-30**	**High salt and lactose**
Meat Bone Meal	20	High ash
Pollard	15	High fibre
Bran	10	High fibre
Brewers' Grains	10	High fibre
Blood Meal	7	Imbalance of amino acids

3.2.5 Performance Benefits

The use of PROLIQ for pig diets is as a cheap source of protein and energy, and as a carrier for liquid feeding systems.

At increasing levels of PROLIQ in the diet liveweight gains decrease. In one experiment using a delactosed whey (DLW) similar to PROLIQ, (36.7% dry matter, 11% protein, 18% lactose, pH 3.6) a linear decline in liveweight gains with increasing levels of the DLW in the diet was noted **(Table 29).** The reasons for this decline included high lactose and salt intakes and possibly the loss of digestible energy from growth activities to be used to warm the liquid diet.

Table 29

Mean daily intakes of nutrients and the growth rates and feed conversion rations of pigs 30-82 kg liveweight, (after Smith *et al* 1984)

	Treatment					
	1	2	3	4	5	6
DLW (g/kg total DM intake)	0	150	250	350	450	610
Daily Intake:						
Meal (kg)	1.93	1.65	1.47	1.28	1.13	0.77
DLW (kg)	—	0.68	1.13	1.59	2.08	2.80
Crude Protein (g)	356	380	398	404	440	485
Digestible Energy (MJ/)	24.7	24.6	24.6	24.1	25.0	25.7
Daily Liveweight gains (/g)	760	739	686	683	666	614
Feed conversion ratio (kg DM/kg liveweight gain)	2.23	2.31	2.48	2.52	2.65	2.98

Reasonable liveweight gains of 614 g/day were achieved at up to 61% DLW in the diet (on a dry matter basis), however the economics of this slower growth against the product's cheap cost must be considered in each piggery.

Dressing out percentages of the carcass and carcass measurements are not affected by the inclusion of PROLIQ or like products in the diet.

Liquid (slurry) feeding systems have been shown to increase growth rates by 10-15% over dry meal feeding. Fewer respiratory diseases occur due to the lower dust levels. The use of slurry feeding with PROLIQ as the carrier would enhance many systems. Warming the slurry also improves both consumption and performance. In one case an increase from 10 to 27°C, boosted consumption by 23% over a 30 minute period. This warming allows more of the digestible energy to be utilised for growth rather than to warm the slurry.

3.2.6. Animal Health

Salt toxicity is the major animal health problem and has been covered in other sections. Free access to good quality water is essential to overcome this potential problem.

High lactose levels in the diet can lead to diarrhoea. The lactose can cause an excessive amount of hindgut fermentation leading to diarrhoea from the proliferation of undesirable micro organisms (clostridia) and to bloat from excessive gas production (a problem more common to the use of whey). The problem is further aggravated by breed differences in lactose intolerance. For instance, Chester White pigs have three times the lactase activity in the intestinal mucosa compared to Hampshire pigs. Thus, Chester Whites have fewer problems in dealing with diets higher in lactose.

Whey fed pigs can also suffer from twisted bowels, particularly sows and heavy finishing pigs consuming large amounts of whey. Generally, running out of whey, switching from acid to sweet whey, and cold to warm are factors which lead to overconsumption predisposing digestive upsets, bloat or twisted gut.

Vitamin deficiencies may occur when the diet composition limits intake. A recent case of vitamin D deficiency in indoor housed pigs fed PROLIQ and bread only (R. Robinson pers. comm.) demonstrated the need to carefully formulate diets.

3.2.7 Feed Comparisons

Primarily, PROLIQ is used to provide a cheap source of energy and protein. Given that PROLIQ contains a good balance of essential amino acids, and amino acids/energy, the relative costs of various commonly used feedstuffs can be calculated **(Table 30).**

Table 30

Costs of protein and energy in common feedstuffs (July 1988)

Feedstuff	Dry Matter (%)	Digestible Energy		Crude Protein	
		MJ/kg DM	Cost (c/MJ)	g/kg DM	Cost (c/g)
Mixed Meal	87	13.0	3.54	186	0.25
PROLIQ	**42**	**13.0**	**0.77-0.92**	**210**	**0.05-0.06**
Whey (fresh)	6	14.8	0.68	133	0.08
Skim milk powder	94	13.0	10.00	350	0.37
Meat/Bone meal	94	10.7	4.27	500	0.09
Dried Blood	94	19.4	4.66	820	0.11

PROLIQ provides energy at a fraction of the cost of other feeds; meal (24%), skim milk powder (8%), meat/bone meal (20%), and dried blood (18%). Only fresh whey provides energy at a slightly cheaper cost however if it is not utilised quickly it can deteriorate rapidly in storage.

PROLIQ is the cheapest source of crude protein; meal (22%), whey (69%), skim milk powder (15%), meat/bone meal (61%), and dried blood (50%). In addition the meat/bone meal and dried blood do not provide a good balance of the essential amino acids.

PROLIQ has a long storage life without deterioration providing a continuous supply all year round.

3.2.8 Feeding Recommendations

The general feeding recommendations for PROLIQ are:

1. Maximum intake limited to 30% of the total dry matter.
2. Clean water must be provided at all times (*ad lib*).
3. Do not feed to sows within 3 weeks of farrowing and during lactation.
4. Supply vitamins (A, C, D, E, K) and micro elements in diet but reduce salt levels.
5. Mix with water at ratios of water/PROLIQ of 1:1 to 8:1, when fed singly.
6. Weaner pigs can be started at 10:1 ratios increasing the PROLIQ concentration gradually to 7:1 (water/PROLIQ). Adult pigs can be fed 1:1 mixes.
7. Always introduce slowly into the diet over 4-5 days.
8. Balance the lower cost for PROLIQ against the slower growth rates likely (compared to meal) to maximise profit.

PROLIQ can be included at levels greater than 30% but it is not recommended due to the variability of individual's intake and the lack of intake control in group fed animals. When fed with meal **Table 31** gives a range of PROLIQ consumptions ranging from 0.4-1.9 litres/pig/day for pigs from 20-85 kg liveweight, and 15-30% of the dietary dry matter as PROLIQ.

Table 31

Daily meal and PROLIQ requirements for different liveweights and % inclusion of PROLIQ (N.Z. Pork Industry Board, 1985)

Liveweight (kg)	Meal Only (kg)	15% PROLIQ		25% PROLIQ		30% PROLIQ	
		Meal (kg)	*PROLIQ (l)	Meal (kg)	PROLIQ (l)	Meal (kg)	PROLIQ (l)
20-25	1.20	1.02	0.43	0.90	0.71	0.85	0.86
25-30	1.40	1.19	0.50	1.05	0.83	0.98	1.00
30-35	1.60	1.36	0.57	1.02	0.95	1.12	1.14
35-40	1.72	1.46	0.61	1.29	1.02	1.20	1.23
40-45	1.85	1.57	0.66	1.38	1.10	1.30	1.32
45-50	2.00	1.70	0.71	1.50	1.19	1.40	1.43
50-55	2.10	1.78	0.75	1.57	1.25	1.47	1.50
55-60	2.20	1.87	0.79	1.65	1.31	1.54	1.57
60-65	2.25	1.91	0.80	1.68	1.34	1.58	1.61
65-70	2.30	1.95	0.82	1.72	1.37	1.61	1.64
70-75	2.40	2.04	0.86	1.80	1.43	1.68	1.71
75-80	2.50	2.12	0.89	1.87	1.49	1.75	1.79
80-85	2.60	2.21	0.93	1.95	1.55	1.82	1.86

*Based on 42% dry matter

To avoid salt toxicity clean *ad lib* water must be provided. Both the total quantity of water and opportunity to access the water is required. When consuming PROLIQ the pig may suddenly require water. If other pigs in the pen choose to do the same then competition could occur. Daily checks on the water supply should be made, particularly where the system is prone to failures and accidental shut off.

Withholding PROLIQ from sows three weeks prior to farrowing and during lactation will minimise the salt effects on milk production and piglet scouring. PROLIQ can be fed at reasonably high levels to dry sows, particularly if it is highly diluted (to levels similar to whey). At these levels of dilution, the total feed can be considered bulky and the lower energy requirements of the sow can be met while still feeding her to appetite.

Vitamin B additions could be cut back in the rations due to the supply in PROLIQ. However, in practice the continued use of a range of vitamins is recommended, particularly if the rest of the diet is low in these compounds (e.g. bread).

Micro elements are required and a general supplement is recommended. PROLIQ does not provide sufficient for the pig. The high level of sodium and potassium in PROLIQ means that salts should be cut back in the rest of the diet.

When PROLIQ is fed separately it should be diluted with water. Weaners can be started at 10 parts water to 1 part PROLIQ (10:1) then have this slowly strengthened to 7:1. Adult pigs can be fed 1:1 mixes. The use of hot water when mixing increases the temperature allowing better utilisation of the energy for growth.

In slurry fed systems where PROLIQ is fed in conjunction with meal, offal, garbage, bread, etc., an optimum ratio of water to dry matter is 2-4.5:1.

Where PROLIQ has not been used before, or its use has been interrupted, a slow introduction over 4-5 days should be followed. This is particularly true where no milk based products have been used before. Time for the gut organisms to adapt must be given.

Where PROLIQ is substituted into all meal feeding regimes a performance decline may be noted. The longer time to produce desirable finishing weights must be offset against the lower costs. The optimum substitution level varies according to the meal and transport costs, and the efficiency of feed use. An economic analysis should be carried out to find the optimum.

3.2.9 Feeding Systems

Delivery and storage requirements are the same as for dairy (refer section 3.1.9). Additional facilities to pre-mix diets and/or dilute PROLIQ are required. Normally old whey feeding facilities have enough volume for both storage and mixing of PROLIQ. The condensed nature and long storage life means lower storage volumes are needed compared to whey.

The use of hot water or mixing hot 'cooked' feeds with PROLIQ will improve consumption and energy conversion to growth. A system to achieve this is encouraged.

A single pumping facility can service several buildings. Plastic or stainless steel pipes resist corrosion the best. Trough construction materials include concrete, stainless steel and plastic. Concrete will be eaten away with time. Trough design can strongly influence feed consumption and wastage. This should be observed closely to minimise losses and maximise growth.

Water should be provided in close proximity to the feed trough with ample space and volume to satisfy several pigs at once.

The increased volume of urine produced at high levels of PROLIQ inclusion may require additional wastage handling facilities but no more than whey.

3.3 Calves

3.3.1 Introduction

Calves require separate consideration for PROLIQ feeding. They have changing nutritional requirements and abilities to utilise PROLIQ as they progress from the pre-ruminant (monogastric) to ruminant status. In addition there are many different ways to raise calves depending on targeted weaning weights and ages, required growth rates and feeding systems. Special care is required when PROLIQ is fed to calves. Although many farmers rear calves successfully using PROLIQ, problems can arise due to over consumption where excessive salts may lead to health problems and in extreme cases death.

The aim of this section is to highlight the basic calf requirements and how PROLIQ may be incorporated into their diets.

3.3.2 Dietary Requirements

The maximum voluntary dry matter intake of young calves is dependent on the form of the food. Up to liveweights of 70 kg more dry matter can be consumed in liquid than in dry form. In addition, the energy in the liquid diet is more efficiently utilised by monogastric digestion than that of dry diets by ruminant digestion. Therefore, in liquid form the same amount of dry matter yields more net energy. This enables the calf to obtain more net energy from a liquid diet up to 100 kg liveweight even though dry matter consumption is lower for a liquid diet than in a dry diet to a ruminant calf.

Intake of liquid diets is strongly influenced by the dry matter content. With diets of low dry matter content (e.g. skim milk) the total volume ingested is greater than say whole milk, but the total dry matter intake is lower. Calves of a particular weight tend to consume dry matter to achieve a particular energy intake, but may be prevented from doing this if the volume is too great. With liquid diets no difference has been found between Jersey, Friesian and Ayrshire breeds in the total dry matter/intake/unit liveweight (60-100 kg).

Energy, as for other animals, is required for maintenance and growth. Milk fed-calves (pen-fed) require 0.3 MJME/kg $LW^{0.75}$ day. For calves this equates to daily energy requirements for maintenance of 4.82-10.41 MJ/day.

The energy required for growth depends on the net energy content of the tissue and the efficiency with which ME fed above maintenance is used.

Growth in the young animal is mainly in the form of muscle containing approximately 80% water and 20% protein, compared to mature animals where gain is predominantly adipose tissue (20% water and 80% fat). As protein contains less energy than fat, a lower energy input is required per kg gain compared to older animals, approximately 11.4 MJ/kg gain.

For different liveweight gains the energy requirements of calves can be calculated **(Table 32).**

Table 32

Total energy requirements for young calves from birth to weaning, MJ ME/day (after Homes *et al* 1984).

Assumptions: ME maintenance = 0.43 MJ/kgLW$^{0.75}$/day ME gain = 11.4 MJ/kg gain					
Liveweight (kg)	Liveweight Gain (kg/day)				
	0.00	0.25	0.50	0.75	1.00
25	4.82	7.67	10.52	13.37	16.22
30	5.5	8.35	11.20	14.05	16.90
35	6.19	9.04	11.89	14.74	17.59
40	6.84	9.69	12.54	15.39	18.24
45	7.48	10.33	13.18	16.03	18.88
50	8.08	10.93	13.78	16.63	19.48
55	8.69	11.54	14.39	17.24	20.09
60	9.29	12.14	14.99	17.84	20.69
65	9.85	12.70	15.55	18.40	21.25
70	10.41	13.26	16.11	18.96	21.81

Young calves require protein in larger proportions for growth than older animals as it lays down a higher proportion of body tissue as protein. Maintenance requirements are in the range of 11-31 g tissue protein/day for 25-80 kg liveweights. This equates to dietary protein requirements (as digestible crude protein) ranging from 24-206 g/day for a 40 kg calf and 0-1 kg liveweight gain **(Table 33).**

Table 33

Digestible crude protein requirements of a 40 kg milk fed calf (after Holmes et al 1984)

Liveweight gain (kg/day)	Tissue protein requirements (g/day)			Digestible Crude Protein (g DCP/day)	Milk (kg/day)
	Maint'nce	Gain	Total		
0.00	19	—	19	24	0.7
0.25	19	40	59	74	2.3
0.50	19	78	97	121	3.8
0.75	19	132	132	165	5.1
1.00	19	165	165	206	6.4

The balance of protein and energy is also important. In whole milk based diets a ratio of 11-12 g protein/MJ energy is achieved. In milk substitute diets ratios of up to 23.3 g/MJ can occur. In these diets an excess of protein is supplied

because the recommended feeding levels have to be based on providing sufficient energy for growth and maintenance **(Table 34).** The excess protein is broken down and excreted as urea in the urine. Increasing the energy levels in these diets would require less of the diet to be fed per day.

Table 34

Mean composition of whole milk and milk substitutes on a fresh weight basis (after Holmes et al 1984)

	Total Solids (g/kg)	Fat (g/kg)	Protein (g/kg)	Lactose (g/kg)	Ash (g/kg)	Energy (MJ/kg)	Protein/ Energy g/MJ
Wholemilk (fat corrected)	130	40	35	48	7	3.0	11.7
Colostrum	145	45	46	46	8	3.4	13.5
Wholemilk powder	960	300	260	350	50	21.9	11.9
Butter milk powder	960	90	360	440	70	18.1	19.9
Skim milk powder	960	10	380	480	90	16.3	23.3
Proprietary milk powder	960	180	300	410	70	19.5	15.4
PROLIQ	**420**	**10**	**90**	**170**	**90**	**6.3**	**14.3**

Mineral requirements are high for young, fast growing animals. Normally milk and pasture based diets provide most of the required minerals. Milk alone does not supply adequate calcium to ensure maximum bone density in calves. However, sufficient is provided to prevent rickets. The magnesium concentration in milk is also marginal and calves fed for prolonged periods without access to grazing will develop hypomagnesaemic tetany.

For milk fed calves iron (Fe) is grossly deficient and Copper (Cu) could also be a problem. The concentration in the milk varies according to the cow's diet. Generally pasture contains sufficient trace elements for the young stock.

Vitamins for the young calf can be a problem, especially on milk substitute diets. In diets with a low milk fat content (e.g. skim milk powder) there is insufficient of the fat soluble vitamins (A, D, E) to meet the calf's requirements. As pasture is incorporated into the diet sufficient is provided.

For milk substitute diets additional minerals and vitamins are recommended.

3.3.3 Nutritive Value of PROLIQ

PROLIQ is a rich supply of proteins and lactose in a liquid form. It is easily consumed and digested by calves. When compared to whole milk, milk substitutes and concentrates on a dry matter basis **(Table 35)** a clearer picture emerges.

Table 35

Comparison of common feedstuffs for calves on an equivalent dry matter basis

Feedstuff	Fat (g/kg DM)	Protein (g/kg DM)	Lactose (g/kg DM)	Ash (g/kg DM)	Metab-olisable Energy (MJ/kg/DM)	Protein/ Energy Ratio g/MJ
Wholemilk (fat corrected)	308	269	369	54	23.1	11.6
Colostrum	310	317	317	55	23.4	13.5
Whole milk powder	313	271	365	52	22.8	11.9
Butter milk powder	94	375	458	73	18.9	19.8
Skim milk powder	10	396	500	94	17.0	23.3
Proprietary milk powder	188	313	427	73	20.3	15.4
Meal Concentrate		110			13.0	8.5
PROLIQ	**24**	**210**	**405**	**214**	**13.0**	***16.2**

* Value is higher than in table 34 as 1 litre PROLIQ = 1.15kg by weight

If whole milk is considered a near optimum feed then PROLIQ provides significant quantities of the lactose (110%), and protein (78%). Fat levels are only 8% while ash is four times too great for the calf. Energy levels are low (56%) in comparison to milk on a dry basis but 2.1 times greater on a liquid basis.

Higher lactose levels in PROLIQ are normally beneficial to the calf. Lactose is readily utilised and provides a good source of energy.

The protein levels (although lower than milk on a dry matter basis) are above the minimum levels to balance the energy in PROLIQ. The proteins are readily digested as are all milk proteins.

Ash (salt) levels in PROLIQ are excessive for the pre-ruminant calf. As the calf develops into a true ruminant its ability to cope with the high salt level increases. The stage at which this occurs is dependent on rumen development which is related to the introduction of roughage (pasture, hay, concentrates) into the diet. Dilution or mixing of PROLIQ with other products is required to ensure problems are not faced.

Magnesium levels are adequate in PROLIQ at 8 times the calf's requirements (2000 mg/kg DM against 250 mg/kg DM). Iron, manganese, copper, zinc, cobalt and iodine are too low for the calf's needs and extra would be required, or supplied from other dietary constituents.

B group vitamins are abundant in PROLIQ. For milk substitute diets usually only B12 is required at 30 ug/kg dry matter. PROLIQ provides three times the required levels (100 ug/kg DM). Fat soluble vitamins (A, D, E) would be required from other sources.

3.3.4 Limitations to Use

The limitations to the use of PROLIQ in calves' diet revolve around:

- high salt content
- low fat content
- lactose content
- protein/energy rations
- excessive consumption by calves

PROLIQ has higher ash levels than whole milk (94 times on a dry matter basis and 11-13 times as a liquid). For the pre-ruminant calf these levels are excessive. PROLIQ must therefore only form a part of the diet and be diluted or mixed with other dietary constituents to lower the salt concentration and limit total PROLIQ intake. Introduction should be at dilutions of 10:1. As the calf grows and the rumen develops with increasing roughage ingestion, PROLIQ strength can be increased to about 7:1 (water:PROLIQ). The dilution limits total intake as the calf's stomach is small. As an added precaution, the total amount made available each day should be restricted.

Low fat levels are limiting in several ways. Firstly insufficient fat soluble vitamins (A, D, E) are supplied. If milk or pasture is fed in conjunction with PROLIQ these will be supplied. Secondly, high salts and or lactose levels in conjunction with low fat can lead to an increased incidence of diarrhoea. Apparently the high salts increases the rate of passage from the abomasum. Additional fat has an ameliorating effect by delaying the passage of ingesta from the abomasum.

Intakes greater than 200g lactose/day can soften faeces and excessive quantities (>500 g/day) can cause fermentive diarrhoea, if fat levels in the diet are also low. This equates to about 2.5 litres PROLIQ/day. This is 15.75 MJ ME/day equivalent which could supply the total calf's requirements up to 65 kg and 0.5 kg/day liveweight gain. Realistically, excessive salt would cause diarrhoea before high lactose levels.

Bloat, caused by excessive gas production in the abomasum or rumen of the calf can occur when feeding low fat milk substitutes. It occurs immediately after feeding (it can occur with whole milk also) and is associated with the proliferation of undesirable or excessive organisms in the abomasum, possibly *E. coli,* or *lactobacilli* as a result of too high a level of carbohydrate in the diet (e.g. lactose).

Protein/energy ratios are higher than for whole milk but these are unlikely to cause limitations if PROLIQ is limited in the diet due to high salt levels.

Excessive consumption by calves is the major problem when feeding PROLIQ. This can lead to salt poisoning, diarrhoea and bloat as described above. Death after excessive consumption can be rapid (within hours) and is usually limited to a few cases in the group. It is imperative that each calf's intake of PROLIQ be limited. If single calves in a group drink faster or are allowed too much, then the total group's PROLIQ intake must be decreased.

Individual feeding gives greater intake control. Feeding too little will be much safer and minimise losses.

3.3.5 Performance Benefits

The use of PROLIQ in diets is principally to access cheap energy and protein. Performance benefits are related more to ruminant calves (i.e. post weaning) where the higher energy levels in PROLIQ compared to pasture allow faster growth rates.

As a liquid, dry matter intakes are higher in total for PROLIQ. This allows a greater energy intake and hence liveweight gain than for calves fed pasture and/or quality hay. For instance, a 70kg Friesian calf at weaning, with an intake of 1.5kg DM/day could achieve growth rates up to 0.63 kg/day when fed PROLIQ in conjunction with pasture compared to 0.47 kg/day on pasture alone. **(Table 36).** Growth rates are likely to be higher than this as total dry matter intake could increase when PROLIQ is fed in conjunction with pasture.

Table 36

Potential liveweight gains for a 70 kg Friesian calf fed 1.5 kg DM/day on various diets

Assumptions:	Maintenance requirements = 10.41 MJ ME/day Energy for liveweight gain = 11.4 MJ/kg liveweight Pasture Energy = 10.5 MJ/kg DM	
Diet	Energy Intake (MJ ME/day)	Liveweight Gain (kg/day)
Pasture	15.75	0.47
Pasture (90%) + PROLIQ (10%)	16.13	0.50
Pasture (80%) + PROLIQ (20%)	16.50	0.53
Pasture (70%) + PROLIQ (30%)	16.88	0.57
Pasture (60%) + PROLIQ (40%)	17.25	0.60
Pasture (50%) + PROLIQ (50%)	17.63	0.63

The other major performance benefits relate to higher growth rates over the first summer when pasture quality is low (and may be in limited supply) and to the conditioning of calves to accept PROLIQ, a real benefit when milking cows or beef animals require PROLIQ in later life.

3.3.6 Feeding Recommendations

SPECIAL NOTE: The following recommendations are based on theoretical limitations to use. Variations in rumen development, other dietary components, feeding systems and calf management may affect calf performance and tolerance to PROLIQ. The recommendations given here should only be used with caution and the calves' intake and health monitored closely at all times.

The general recommendations for feeding PROLIQ to calves are:

1. Limit PROLIQ intake to a maximum of 50% of the total dry matter ingested.
2. Dilute PROLIQ with water beginning at 10:1 (water:PROLIQ) and slowly increasing its strength to 7:1. Alternatively mix with whole milk at concentrations no greater than 3.3:1 w/w (milk/PROLIQ).

3. Introduce PROLIQ slowly into the diet (4-5 days) gradually increasing the proportion in the feed mix. Watch for any health problems. The same procedure should be followed when increasing the quantity or concentration of PROLIQ.

4. Do not allow calves to over consume. Limit each calf's intake of PROLIQ if problems occur.

5. When feeding high levels of PROLIQ to young calves maintain high fat levels in the diet by providing whole milk or whole milk powder.

6. If diarrhoea, bloat or salt poisoning occurs, restrict PROLIQ intake.

7. Provide plenty of water within easy reach of the PROLIQ feeding facility.

Limiting PROLIQ to 50% of the dry matter reduces the risk of salt poisoning. Because of its concentrated liquid form, it is easy for the calves to ingest too much. Dilution with water may restrict intake as the calf becomes full quickly. The large amount of water also helps the calf get rid of the excess salts. Alternatively, offering a limited amount per day, substituting part of the milk volume, or mixing with milk helps limit the intake.

Mixing PROLIQ with whole milk reduces the volume of milk required and the total quantity of feed required due to the mix's higher energy content **(Table 37).** PROLIQ, at approximately ⅓ the cost of whole milk, reduces the cost of raising the calves.

Table 37

Estimated Compositions of various whole milk/PROLIQ mixes and diluted PROLIQ

Product Mix		Milk	Milk/ PROLIQ (3.3:1)	Milk/ PROLIQ (6.6:1)	Water/ PROLIQ (7:1)
Total solids	(g/kg)	130	197	168	53
Fat	(g/kg)	40	33	5	1
Protein	(g/kg)	35	48	42	12
Lactose	(g/kg)	48	76	70	22
Ash	(g/kg)	7	26	18	12
Energy	(MJ/kg)	3.0	3.8	3.4	0.7
Density	(kg/l)	1.05	1.07	1.06	1.02
Volume required to provide 10 MJ ME	(l)	3.2	2.5	2.8	14.0

Introducing PROLIQ to the diet slowly allows time for the stomach organisms to adjust. This minimises digestive upsets and allows time for corrective action if problems arise.

As discussed previously, over consumption by calves occurs easily. Feeding calves singly, matching calves with similar drinking speeds, removing fast drinkers from the group when they've had sufficient, or limiting the PROLIQ further will help control this. Overconsumption is a larger problem with younger calves and where water is not freely available.

High levels and salt and/or lactose in conjunction with low fat can lead to diarrhoea, or bloat in severe cases. Mixing PROLIQ with low fat milk substitutes (e.g. skim or butter milk powders) is not advised for this reason.

Providing clean fresh water in close proximity to PROLIQ assists in several ways. It helps limit consumption by providing a gut 'filler', satisfies the thirsty calf which has consumed too much PROLIQ and consequently salts, and helps the calf get rid of the salts by assisting kidney function.

3.3.7 Feeding Systems

A variety of methods to raise calves are practised in New Zealand. These include:

— restricted feeding to limit the expense of calf raising but still achieve target liveweights (mainly for dairy replacement purposes)

— feeding to appetite (*ad libitum*) to maximise weight gains for dairy replacements and beef.

— early weaning to reduce the quantity of milk (or milk substitutes), time and labour involved in calf raising.

Each case has its own advantages and disadvantages. In all cases the costs and time involved must be weighed against the need to achieve target liveweight or liveweight gains.

PROLIQ can be incorporated into all these systems as it can be fed as a mix through buckets, calferterias, etc. either on a restricted or *ad lib* basis. As a liquid it is easily mixed with water or milk.

As a high energy source (on a liquid basis) it can provide a good base for the calf especially at weaning time when pasture may not provide sufficient energy. Liveweight gains at weaning are usually checked at this stage and meal concentrates are fed to overcome this. PROLIQ could be used to replace some, if not all the meal requirements. It cannot however be used to help develop the rumen. Roughage in the form of pasture, hay or meal is required.

Whatever feeding system is used the overriding guideline must be to control intake and watch the calves closely when PROLIQ is fed as problems do occur from excessive consumption.

3.4 OTHER ANIMALS

Very little information is available on the use of PROLIQ for other animals. Any use of PROLIQ for these should be attempted with care.

In general, PROLIQ should be suited to other ruminants, sheep, goats and deer. Inticement to consume, behavioural differences and performance benefits are likely to vary a lot.

Other monogastrics may tolerate low levels of PROLIQ but high salt and/or lactose may strongly influence its likely use and serious health problems may occur.

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ABBREVIATIONS

CP	crude protein
CW	carcass weight
d	day
DCP	digestible crude protein
DE	digestible energy
DM	dry matter
FCM	fat corrected milk containing 4% milkfat
g	gram
ha	hectare
hr	hour
kg	kilogram
l	litre
LW	liveweight
LWG	liveweight gain
ME	metabolisable energy
MF	milkfat
min	minute
MJ	megajoule
NPN	non protein nitrogen
s	second
TP	total protein
w/w	weight/weight normally on a fresh (wet) basis
yr	year