The Calcium Story

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Healthy cows produce more milk, have better reproductive performance and have lower culling rates than their less thrifty herd mates.

Inclusion of Calcium as part of a balanced diet is a critical component of maintaining healthy cows!

AB LIME

healthy COW

AB LIME

Why is Calcium Important?

Calcium is a mineral essential to the health and well being of dairy cows. Calcium is a major material used in the development of bones and teeth; in fact 98% of the calcium in the body is located within the skeleton. For this reason calcium is critically important in the growth of young stock. If calcium is deficient, heifers will fail to mineralise new bone leading to poor growth rates. In older cows a deficiency of dietary calcium forces the animal to draw calcium from the bone to maintain normal blood calcium levels leading to fragile and porous bones.

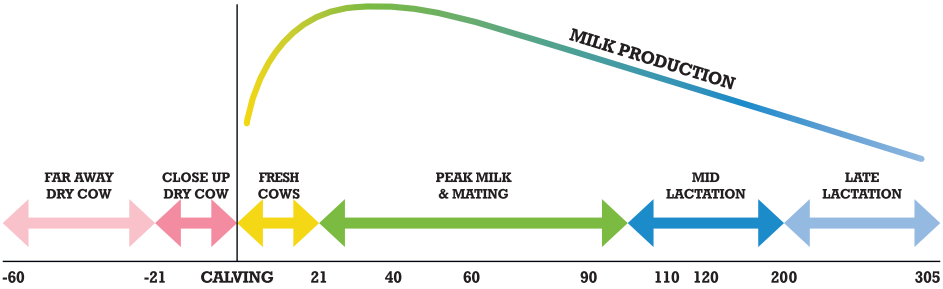
At the cellular level, calcium is an important chemical messenger; it is a critical component in transmitting nervous tissue impulses, muscle contraction and blood clotting. At a deeper level calcium is involved in enzymatic processes involved in hardening of the hoof horn.

We must not forget that calcium is also a very **important component of milk**. It is this calcium which is one of the reasons milk is an important component of human nutrition. Regardless of the calcium status of the cow, even during a severe dietary deficiency, she will maintain the concentration of calcium in the milk. A cow can contribute 20 to 30 g of calcium to colostrum and milk. This is an incredible feat given that a 500 kg cow has only approximately 2.5 g of calcium readily available in her blood plasma pool. Keeping the blood plasma calcium levels steady is critical to cow health. As such, in order to minimise the amount of calcium mined from the cow's bones, **it is critical to provide adequate amounts of supplemental calcium in the diet of lactating cows.**

HOW MUCH CALCIUM DO COWS NEED?

Calcium is required by all dairy cows; the amount required depends largely on the stage of lactation.

PHASES OF LACTATION



FAR AWAY DRY COW

This phase is from dry off to 21 days pre-calving. This is 'cow down-time'. During this phase the cow should be resting and re-grouping in preparation for the upcoming lactation. She is not lactating and the nutrient demands of the foetus are relatively low. As such, the calcium requirement for far away dry cows is relatively low: 0.6% of dry matter intake. This requirement can generally be met by the typical Southland wintering rations.

CLOSE UP DRY COW

The close up dry cow period is the most important phase of the entire lactation. How cows are managed in the three weeks leading up to calving will directly impact the productivity, health and reproductive efficiency of the entire lactation to come. The calcium requirement during this phase is 0.7% of dry matter intake. This level of calcium is typically provided by the wintering rations in Southland. **Supplemental calcium should <u>not</u> be fed during the Close Up Dry Cow phase[1].**

How mineral nutrition is managed during the Close Up Dry Cow phase can have a direct impact on the incidence of metabolic disorders, especially milk fever at calving. The objective in the three weeks leading up to calving is to stimulate calcium metabolism in the cow. This can be achieved by minimising the amount of calcium in the diet. The theory is that a minor decline in blood calcium concentration will stimulate parathyroid hormone (PTH) secretion, which in turn stimulates bone resorption and the production of 1,25-dihydroxyvitamin D.

WHAT IS MILK FEVER?

Hypocalcaemia and milk fever occur when cows do not remove enough calcium from their bones and the diet to meet the demand for calcium lost in milk. Instead they draw the calcium from the muscles and nerves leading to muscle weakness or 'downer cows'.

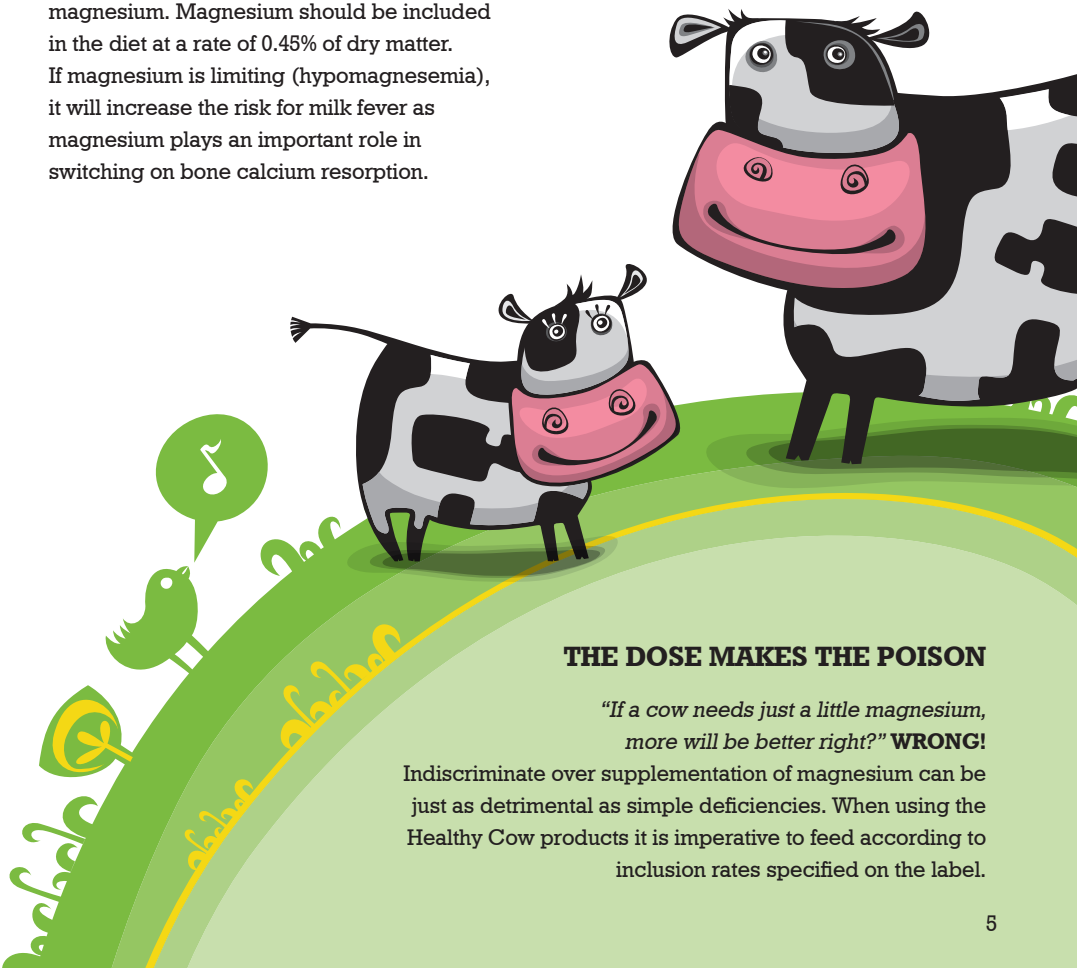
This increases the draw of calcium from the bones, reduces the loss of urinary calcium, and stimulates the intestine to increase calcium absorption efficiency from the dietary calcium supply. Preparing the cow for the increased calcium demand by switching on calcium metabolism prior to calving avoids the two to three day lag it can take to activate these mechanisms in the fresh cow and helps to avoid milk fever. With this process 'switched on' the drain of calcium at calving is more easily replaced when calcium is supplied in the milking ration.

Another essential component of the Close Up Dry Cow program is the inclusion of magnesium. Magnesium should be included in the diet at a rate of 0.45% of dry matter. If magnesium is limiting (hypomagnesemia), it will increase the risk for milk fever as magnesium plays an important role in switching on bone calcium resorption.

The other strategy to mitigate milk fever is toreduce dietary cation content (particularly potassium, K) of the ration as well. For example, Close Up Dry Cows should not be on effluent paddocks or paddocks recently fertilised with potash.

To ensure the balance of nutrients and minerals are optimal for the Close Up Dry Cow, review of the entire ration including the Dietary Cation-Anion Differnce (DCAD) with your nutritionist is advised.

[1] unless under the advice of a veterinarian or nutritionist as part of a Dietary Cation Anion Difference programme



THE DOSE MAKES THE POISON

"If a cow needs just a little magnesium, more will be better right?" **WRONG!**

Indiscriminate over supplementation of magnesium can be just as detrimental as simple deficiencies. When using the Healthy Cow products it is imperative to feed according to inclusion rates specified on the label.

COLOSTRUM & FRESH COWS

The requirement for calcium increases four-fold on the day of calving. All cows develop some degree of hypocalcaemia at calving and for 10 days into the lactation. **In order to mitigate the negative calcium balance the objective should be to prime calcium metabolism pre-calving AND ensure that all cows are adequately supplemented with calcium and magnesium immediately after calving.** The ration should include 1.1% of calcium on a dry matter basis.

It is important to realise that cows on a typical Southland grass based diet DO NOT get enough calcium from the grass to meet their Calcium demand. Review of the average calcium supplied on a grass based diet vs. the calcium requirement for a 500 kg cow shows a calcium deficit of 85 grams through August.

PEAK MILK & MATING

During the phase of peak milk and mating the calcium supplied by the grass is still not sufficient to meet the calcium requirement of 1% of dry matter. As such, **a supplemental source of calcium is critical to drive strong milk yields and maintain cow health.**

It is also important to remember that a key component to reproductive success is to minimise stress to the animal. Changes in nutrition can be very stressful. Therefore if you are going to make a change to the diet (e.g. discontinue calcium dusting) make sure the change is made *after* the cow is successfully bred and the egg is implanted safely in the uterus.

Cows on a typical Southland grass based diet DO NOT get enough calcium from the grass to meet Calcium demand.

DID YOU KNOW...

- Colostrum has twice as much calcium as milk: 2 vs 1 g per litre
- Calcium in colostrum may be 8 - 10 times greater than calcium in the blood supply

MID & LATE LACTATION

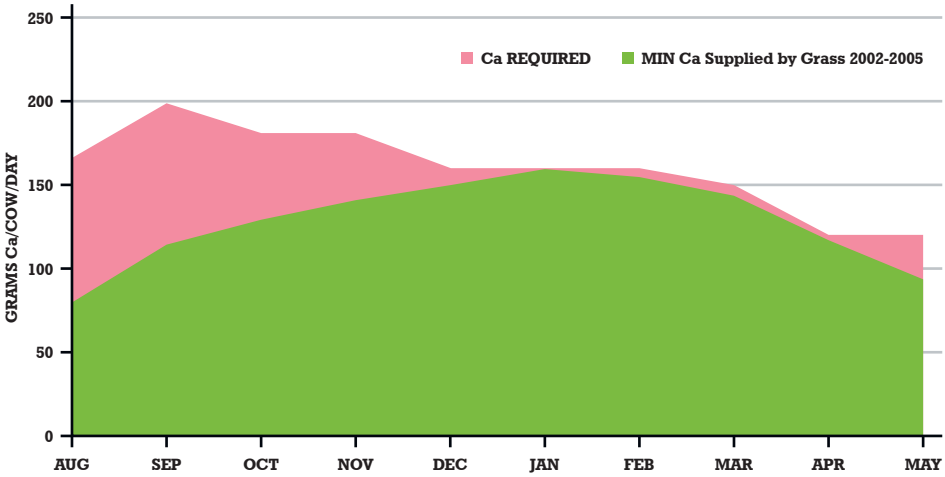
During early lactation, it is suggested that 800 to 1300 g of calcium is removed from the bone to support milk production; this is 13 - 22% of a cow's total skeletal calcium[2]. This calcium is restored to the bone during the last 20 to 30 weeks of the lactation and during the dry period. With the strategy being to 'switch on' bone calcium mobilisation through the Close Up Dry Cow phase by minimising calcium intake, it is imperative to replace the mined calcium during mid and late lactation. Just like replacing body condition lost through early lactation, the ration needs to be designed to replace the lost calcium. As such, it is critical to ensure the cows get adequate dietary calcium.

Based on typical grass intakes for cows in Southland and the minimum grass calcium values for the South Island analysed by Hill Laboratories from 2002 - 2005, there is a risk that adequate calcium requirements are not being met throughout the lactation. This is particularly true during phases of rapid grass growth such as the spring and autumn flush periods when calcium and magnesium uptake in the grass is limited.

It must also be acknowledged that in situations where pasture may be limiting and other feed sources (i.e. PKE and whole crop cereal silage) are used to meet dry matter intake demand, calcium deficit may be further exacerbated.

In order to ensure that cows are receiving enough calcium to prevent autumn flush milk fevers, assist in the reduction of late lactation mastitis, to aid in the development of strong, healthy hooves, and to ensure enough calcium for re-mineralisation of the bones, calcium should be included at 0.8% and 0.6% of the mid and late lactation dry matter intakes, respectively.

MILKING COWS - CALCIUM REQUIRED VS. CALCIUM PROVIDED BY GRASS**



[2] The cow has a store of approximately 6000g of skeletal calcium

** Calcium provided by grass was calculated based on typical grass feeding systems in Southland multiplied by minimum grass calcium as reported by Hill Laboratories data for the South Island from 2002-2005. On farm pasture testing and calcium assessment as part of a balanced ration is strongly recommended.

WHAT HAPPENS IF SUFFICIENT CALCIUM IS NOT SUPPLIED?

Calcium is required by all dairy cows. As outlined, the amount of calcium in South Island pasture is not enough to meet requirements, particularly in early lactation. If these requirements are not met, deficiency symptoms can occur.

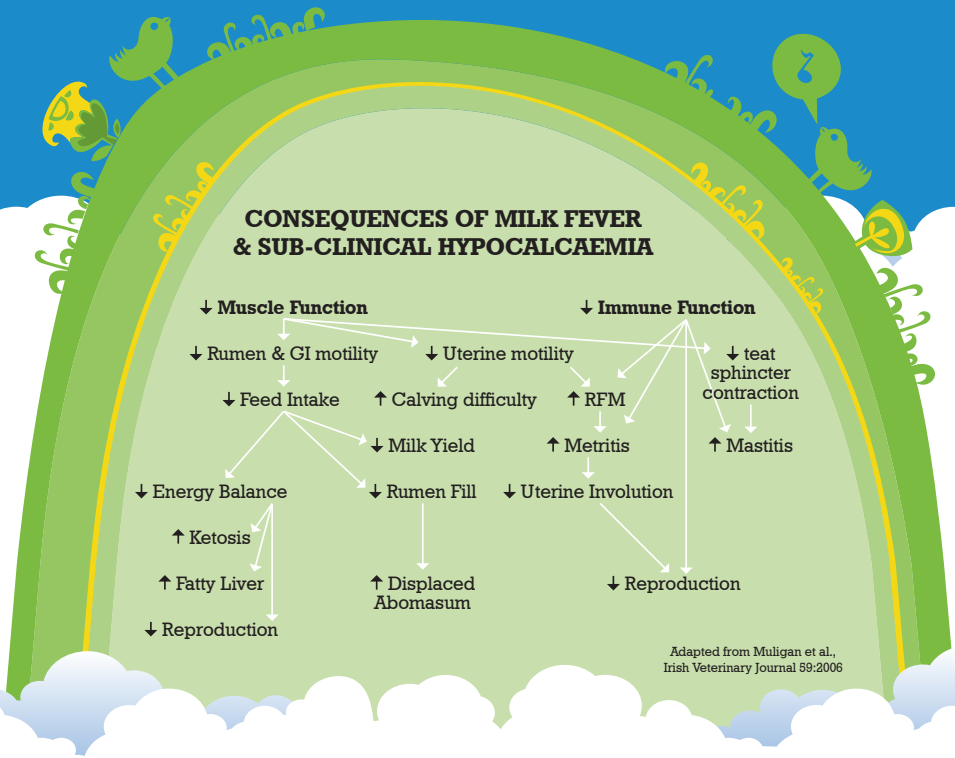
MILK FEVER & SUBCLINICAL HYPOCALCAEMIA

Hypocalcaemia occurs when cows do not remove enough calcium from their bones and the diet to replace calcium lost to milk. When plasma calcium becomes too low, nerve and muscle function are impaired leading to muscle weakness and the clinical condition referred to as milk fever. This can occur at any stage during the lactation.

The average incidence of milk fever across New Zealand is 2%. On individual farms the incidence of milk fever can be as great as 30%. It is also estimated that for every one clinical milk fever case as many as 10 cows could have sub clinical hypocalcaemia. The good news is that hypocalcaemia and **milk fever can be prevented through adequate calcium supplementation as part of a balanced milking cow ration**.

If adequate calcium is not supplemented, and the cow develops sub clinical or clinical milk fever the consequences are far reaching and will impact the entire lactation. The occurrence of milk fever is associated with a cascade effect for other metabolic disorders and infectious diseases. Milk fever cows are up to eight times more likely to develop mastitis, are three to six times more likely to endure calving difficulties, three times more likely to experience retained foetal membranes (RFM) and two to five times more likely to develop displaced abomasum.

As outlined in the flow chart, the two biggest impacts of milk fever are decreased muscle function and depressed immune function. In a clinical case impaired nerve and



muscle function leads to the 'downer cow' situation. In a sub clinical case the muscles of the digestive tract, uterus and teat end may be impaired. Reduced rumen and gut motility leads to reduced dry matter intake. Decreased dry matter intake results in a reduction of energy intake and rumen fill leading to increased risk of other metabolic disorders such as ketosis, fatty liver and displaced abomasum. Hypocalcaemia also inhibits the secretion of insulin, preventing glucose uptake and exacerbating lipid mobilisation increasing the risk of ketosis. The reduction in energy intake negatively impacts both milk yield and reproductive performance. Studies in New Zealand have assessed that sub clinical hypocalcaemia cows in early lactation can give 14% less milk yield as compared to healthy cows.

The uterus is a muscle and milk fever or sub clinical hypocalcaemia will also impact there. If the uterine tone is affected during calving it could result in calving difficulties or prolapse. Post calving if the uterus is not contracting properly, retained foetal membranes is likely to result. A cow with RFM is at higher risk for uterine infection. As a result of RFM and metritis, the uterus may not involute effectively, ultimately decreasing reproductive performance.

Milk fever may also impact the muscles involved in teat sphincter contraction. An open teat sphincter increases the exposure of mastitis causing organisms. The risk of mastitis is also compounded by the reduction in immune function associated with hypocalcaemia.

Research has uncovered the interaction between the metabolic and immune systems. For example, cows experiencing milk fever are under increased stress, as such the level of stress hormone, cortisol, is elevated. This in turn exacerbates immunosuppression, particularly at calving. The reduction in immune function can be linked to the increased incidence of retained foetal membranes, metritis, and mastitis in milk fever cases. Poor immunity early in the lactation will also have an effect on reproductive performance.

RISK FACTORS

Factors which increase the risk for milk fever include advancing age, breed and previous incidence of milk fever. As cows get older the number of bone development cells decrease. This means that fewer bone cells are able to respond to the call for more calcium. At the same time the efficiency of absorption of dietary calcium decreases with age.

Jersey cows are more prone to milk fever because the calcium content of their milk tends to be higher than in Holstein cow milk. In addition, the ability of Jersey cows to absorb dietary calcium is also reduced as compared to Holstein cows.

Cows that have gone down with milk fever or have had sub clinical hypocalcaemia are at risk to succumb to milk fever again. Once the hypocalcaemia develops, the ability of the cow to maintain calcium levels is reduced.

Any cows associated with age, breed or incidence risk factors should receive a full dose of supplemental calcium in the diet.

SIGNS & STAGES OF MILK FEVER

Typically, acute milk fever occurs within a few days after calving. If milk fever occurs within the first 48 hours after calving, it is an indication that the Close Up Dry Cow programme was not adequate. If milk fevers occur within 10 days of calving, the colostrum group did not get enough calcium supplementation. If milk fevers occur at a later stage during the lactation (i.e. autumn milk fever) it is a strong indicator that calcium supplementation is inadequate.

STAGE OF MILK FEVER	STAGE I < 1 HOUR	STAGE II 1 - 12 HOURS	STAGE III
CLINICAL SIGNS	Loss of appetite Excitability Nervousness Hypersensitivity Weakness Weight shifting Shuffling of hind feet	Turn or extend the head Dull Listless Cold ears Dry nose In-coordination of walking Trembling & quivering muscles Inactive digestive tract Constipation Decreased body temperature Rapid heart beat	Inability to stand Loss of consciousness Coma Rapid heart rate Death

Sub-acute milk fever cows experience muscle twitching and tremors; the cows are excitable. In these cases there is often a magnesium deficiency as well. In all cases ensure adequate calcium and magnesium is supplied to the cow.

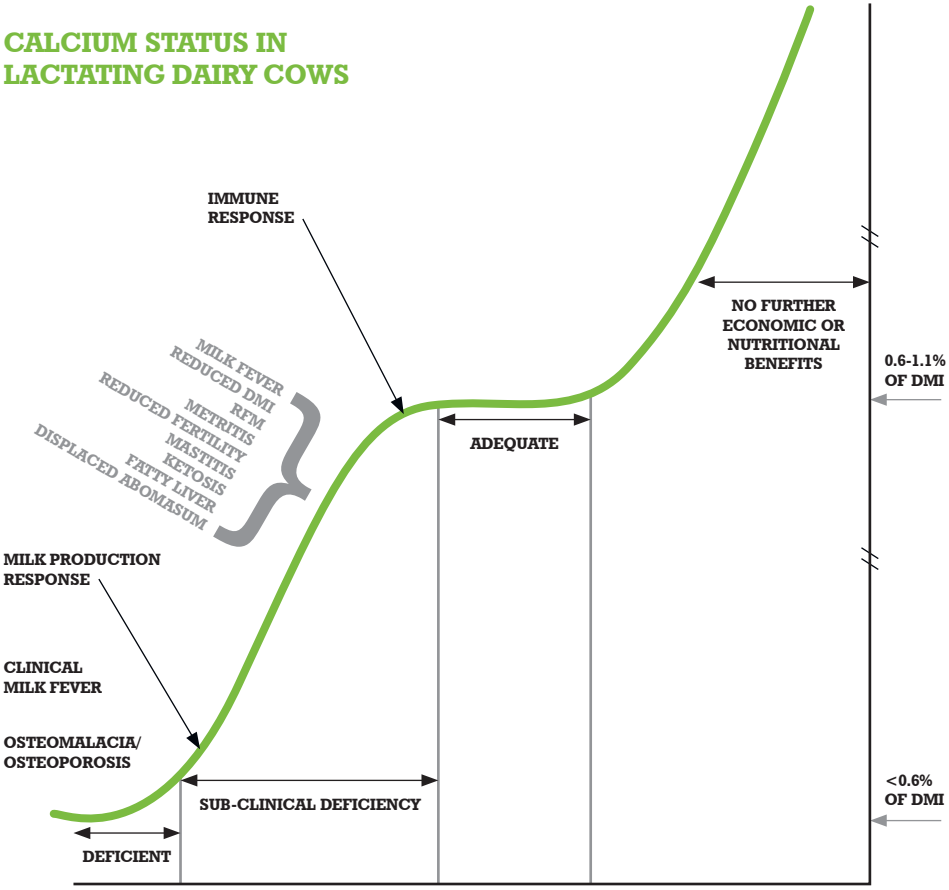
Refractory milk fever is an acute form with poor or no response to treatment. This cow may remain alert, eat and milk but cannot get up.

The best way to mitigate problems associated with milk fever is prevention through a sound Close Up Dry Cow program and adequate supplementation of calcium through the entire season.

CALCIUM STATUS

Calcium status in lactating dairy cows can be partitioned into four phases; calcium deficiency, sub clinical deficiency, adequate status, and no additional benefits.

CALCIUM STATUS IN LACTATING DAIRY COWS



Adapted from Wiske, 1992; NRC, 2001

CALCIUM DEFICIENCY

During the onset of lactation and through the colostrum production phase, all cows experience a degree of calcium deficiency. The large draw of calcium into the milk causes a sudden loss of calcium in the body resulting in acute hypocalcaemia (Milk Fever). The degree and extent of hypocalcaemia will be a function of how well the calcium metabolism mechanism was primed in the Close Up Dry Cow phase and the degree of calcium supplemented in the diet at the onset of lactation.

Cows limiting in calcium over time develop soft, porous, fragile bones and are at risk for developing spontaneous fractures (osteoporosis and osteomalacia). It is interesting to note that because of the body's drive to maintain adequate calcium levels, even in severely compromised animals, blood calcium levels will only be slightly lower than normal.

SUBCLINICAL CALCIUM DEFICIENCY

Cows have evolved to move calcium into milk. If dietary calcium is limiting, she will pull calcium from her bones to maintain the calcium in the blood and milk. **If there is not enough calcium in the diet, she will continue to put calcium into the milk, but will reduce milk yield.** Cows at the low end of the sub clinically deficient scale may have a milk production response to additional calcium.

As has been described, there is a strong correlation between sub clinical hypocalcaemia and the incidence of retained foetal membranes, metritis, reduced fertility, mastitis, calving difficulties, reduced rumen fill, displaced abomasum, fatty liver, and ketosis.

In young calves, inadequate calcium supply in the diet will result in retarded bone growth.

ADEQUATE CALCIUM STATUS

Cows with adequate calcium status as part of a balanced ration will be at optimal performance in terms of milk production, health and reproductive efficiency. Calcium recommendations in this report are based on achieving an adequate calcium status.

Calcium and Healthy Cow Calcium recommendations for Southland grass based rations assuming 1 August calving date and 1 November mating date.

PHASE OF LACTATION	MONTH BASED ON 1 AUGUST CALVING DATE	CALCIUM RECOMMENDATION FOR ADEQUATE STATUS (% OF DMI)	HEALTHY COW CALCIUM* G / COW / DAY
Far Away Dry Cow	June	0.6%	Supplemental calcium not generally required
Close Up Dry Cow	July	0.7%	DO NOT supply additional calcium
Fresh Cow	August / September	1.1%	250 - 300 g
Peak Milk	October	1%	200 - 250 g
Mating	November	1%	150 - 200 g
Mid Lactation	December - February	0.8%	50 - 100 g
Late Lactation	March - May	0.6%	50 - 100 g

* Supplementation rates are based on balancing South Island grass based diets. Cows consuming supplements other than grass (i.e. whole crop cereal silage, PKE, and / or grain) may require higher levels of calcium supplementation. On farm grass testing and consultation with your nutritionist to ensure calcium is balanced is warranted.

NO ADDITIONAL BENEFITS

Dietary calcium absorption will generally meet the calcium requirement as long as the diet contains enough available calcium. The amount of dietary calcium absorption will decrease as dietary calcium increases above the requirement. For this reason the inclusion of calcium at rates higher than 1.1% of DM, offers no nutritional or economic benefits.

High inclusion of calcium is not generally associated with toxicity per se. But there is no further economic benefit for the cost of a higher inclusion rate. In fact, calcium inclusion higher than 1.1% would be taking space in the ration which would be better filled with more energy or protein. Feeding high levels of calcium could cause mineral interactions rendering some trace elements (particularly zinc) less available to the animal.

SOURCES OF CALCIUM

The first source of calcium for Southland dairy cows is pasture. The calcium content of the grass depends on the growing conditions and stage of year. South Island pasture data gathered by Hill Laboratories notes that calcium levels can range from 0.56% to 0.95%. Of the calcium supplied by the grass only approximately 30% of it is available for use by the cow.

As demonstrated in the graphs previously, supplemental calcium is required to meet the requirements of milking cows, especially in early lactation.

The degree to which mineral sources can be utilised by the cow, or bioavailability of calcium in mineral supplements is generally more available than the calcium in forages and common feedstuffs. The efficiency of absorption factor is assigned based on the solubility of calcium within the mineral source. Healthy Cow Calcium is made with calcium carbonate sourced from local limestone deposits and is ground to a particle size of 37μ making it highly bio-available.

SOURCES OF CALCIUM

SOURCE	EFFICIENCY OF ABSORPTION[3]	% ELEMENTAL CALCIUM	Ca ABSORBED g/100g
FORAGES			
Pasture	30%	0.56 - 0.95[4]	0.17 - 0.29
Whole crop cereal silage	31%	0.2 - 0.5[5]	0.06 - 0.16
Triticale	30%	0.2 - 0.6[6]	0.06 - 0.18
CONCENTRATES			
PKE	unknown	0 - 0.84[7]	unknown
Barley grain	60%	0 - 0.22[8]	0 - 0.13
Molasses	60%	1[9]	0.60
MINERAL SUPPLEMENTS			
$CaCO_3$ Healthy Cow Calcium	75%	35	26.3
DCP	85%	20[10]	17.0
Calcium sulphate (dehydrate)	90%	21[11]	18.9

[3] CPM Dairy Ration Analyser and NRC, 2001. [4] Hill Laboratory data, 2002-2005.
[5, 6, 7, 8] Dairy One Laboratory data. [9] CPM Dairy Ration Analyser. [10,11] NRC, 2001.

SUMMARY

South Island pastures do not always supply enough calcium to meet the requirements for dairy cows, particularly in the early spring. The benefits of ensuring adequate calcium for lactating cow diets are many. In order to optimise health, production and reproduction calcium should be included as part of a balanced diet for the entire lactation.

BENEFITS OF SUPPLEMENTAL CALCIUM AS PART OF A BALANCED RATION

- Stimulate appetite post-calving
- Decrease downer cows
- Optimise body condition post-calving
- Drive peak milk production sooner and higher
- Improve reproductive performance
- Bolster immune function
- Help mitigate mastitis and uterine inflammation
- Replenish calcium stores drained through the period of negative calcium balance (i.e. calving and peak lactation)
- Ensures enough calcium for milk production and calcification of the foetal bones in mid to late lactation
- Promotes hoof hardness to help mitigate lameness

WHAT ARE ESSENTIAL MINERALS?

Essential minerals are components of nutrition which are essential for body functions.

There are two categories of essential minerals for dairy cows. Macro-minerals are included at relatively higher rates and are expressed as a percent of the dry matter in a feed. Trace elements are required in very small amounts expressed as parts per million or milligrams per kilogram.

A LIST OF THE ESSENTIAL MINERALS REQUIRED BY DAIRY COWS:

MACRO MINERALS	CHEMICAL SYMBOL	TRACE ELEMENTS	CHEMICAL SYMBOL
Calcium	Ca	Iodine	I
Phosphorus	P	Iron	Fe
Magnesium	Mg	Copper	Cu
Sodium	Na	Cobalt	Co
Potassium	K	Manganese	Mn
Chlorine	Cl	Zinc	Zn
Sulphur	S	Selenium	Se

GLOSSARY

Far Away Dry Cow	In calf Dry Cow
Close-up Dry Cow	21 days pre calving
Fresh Cow	First 21 days post calving
Metritis	Inflammation of the Uterus
RFM	Retained Foetal membranes
Uterine Involution	Return of uterus to normal size post calving
Uterine motility	Uterine Muscle contraction
Abomasum	4th and final stomach of a cow

Healthy Cow
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