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Dietary Phosphorus Requirements of the Modern Dairy Cow

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Introduction – Phosphorus Overview

Phosphorus is the second most abundant mineral in the animal body, with about 80% found in the bones and teeth (Suttle, 2010). The primary role of P is not surprisingly, the formation and maintenance of bone structure. P is stored in bones at a 2:1 ratio with Ca. Think of bricks and mortar, with P being the mortar. One is not stored without the other, and without adequate supply of either mineral, then bone maintenance/ mineralisation will not occur (Horst, 1986).

The remaining 20% of P, is widely distributed in the fluids and soft tissues of the body where it has many functions which include, but are not limited to, energy utilisation and transfer, a component of DNA structure, fatty acid transport and protein synthesis (Suttle, 2010).

Phosphorus deficiency

Under normal conditions, a P deficiency in dairy cows will result in poor appetite, poor production, pica (craving and consumption of abnormal materials such as soil, stone, wood, and bones), and reproductive disturbances/ infertility (Brooks Hv, 1984; Suttle, 2010). Phosphorus is the mineral most frequently associated with infertility in dairy cattle (Moellers & Riese, 1988).

A moderate deficiency in P may be associated with cows not conceiving when mated, while a more severe deficiency can delay postpartum oestrus (cycling activity post calving) due to inactive ovaries (Kincaid, Hillers, & Cronrath, 1981; Moellers & Riese, 1988). Puberty in heifers may be delayed due to a P deficiency too, studies of heifers showed 2.8-3.7 services per conception for heifers on a P deficient diet, this reduced to 1.3 with P supplementation (Moellers & Riese, 1988). It is also possible for only appetite and milk production to suffer from a P deficiency, while fertility remains normal (Suttle, 2010).

New Zealand dairy farms are seeing an anecdotal increase in empty rates, and poor 6 week in calf rates on farms that are feeding an increasing amount of fodder beet as their winter feed. It is well known that fodder beet has very low mineral concentrations, especially P. Fodder beet has 30 – 50% of the P that is found in either pasture or kale and is well below NRC recommendations for P supplementation of dairy cattle (Council, 2001; Suttle, 2010). This reduction in fertility, with the reduction of P available to replenish bone reserves through the dry period is no coincidence. Phosphorus reserves in milking cows only generally begin to improve in late lactation, relying on the dry period to cement this (Horst, 1986).

If the cow's ability to replenish her P reserves throughout the winter period are restricted by her diet, then the cases that we are beginning to see with infertility, downer cows, and poor lactation performance will only increase. Farms that are already experiencing these issues to any degree will not be able to rectify this by only supplementing P through the dry period. There is a maximum rate of P absorption and bone mineralisation, the 6-10 week dry period will not be long enough to build adequate reserves. P supplementation must start earlier than when the cows begin eating fodder beet if the P deficiency is to be rectified.

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Absorption and Availability of Phosphorus

Dietary P availability can be influenced by dietary constituents. If macro nutrients protein or energy are low, then availability of P can be reduced (Horst, 1986). There are many known mineral interactions that will affect the absorption and uptake of P, examples of these are excess Ca, K and NO_3. High dietary Ca, magnesium, aluminium and iron have all been shown to form insoluble complexes with P, thus making them unabsorbable (Brooks Hv, 1984; Horst, 1986). This is especially concerning with feeding fodder beet, as there is a large degree of soil consumed with the beet, the soil contains relatively high concentrations of iron in soil to form these complexes, further reducing the absorbable P supply to the animal.

Further reducing the availability of P to the ruminant through the NZ winter period is the lack of intense sunlight. Sunlight is required to produce vitamin D in the animal which is required to regulate Ca and P absorption, if there is no active vitamin D, then Ca and P absorption will not occur (Horst, 1986; McGrath, 2015; Suttle, 2010).

The absorption, and storing of P into the bone matrix has a finite rate. Excessive supplementation beyond the animals capacity to absorb will simply result in the excess being excreted in the manure (Beede, 2003). The below figure (figure 1) demonstrates that P excretion will increase linearly, at a 1:1 ratio as excess P is supplemented. This is important for P supplementation throughout the winter, where adding excessive amounts of P to the diet will not increase the rate of P absorption. Deficiencies from previous seasons on beet cannot be rectified by additional "slug" feeding over a short period of time.

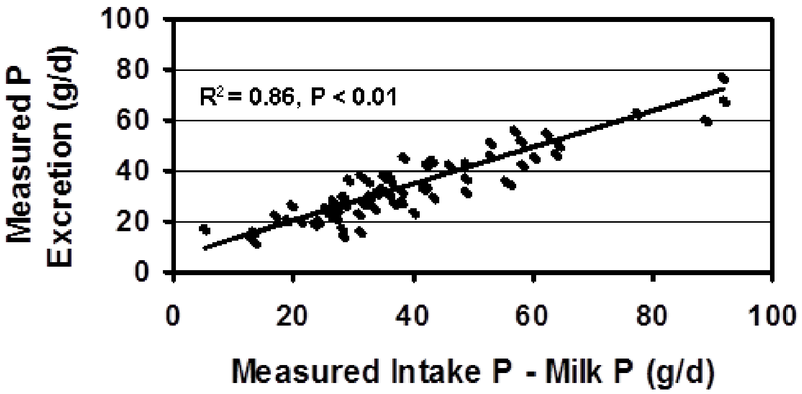

Figure 1. Measured phosphorus excretion versus P intake minus milk P secretion from research results from the scientific literature (Beede and Davidson, 1999).

Practical Phosphorus Supplementation

As P is stored in a 2:1 Ca:P ratio in the bones, this needs to be replicated in feed for the dairy cow. There are a large number of studies that have identified that a low ratio of Ca:P of less than 2:1 is not only hindering P and Ca absorption, but is associated with reduced performance and reproductive problems in cows (Horst, 1986; Kincaid et al., 1981; Manston, 1967). However, a large excess of Ca over P can reduce protein and carbohydrate solubility (Horst, 1986). Therefore, it is critical to have not only Ca and P in the right ratios, but all the other minerals in balance to achieve the most efficient absorption. Efficient absorption is not

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only beneficial to the cow, but to the bill payer too, as unnecessary money is not spent on excess, or unbalanced minerals where efficiency of absorption, production, or both is limited.

Recently the most common P supplementation has been di calcium phosphate (DCP) which despite the name, has similar levels of Ca and P (a ratio of 1.3:1). Additionally the availability of P is highly variable in DCP and is dependent on quality, manufacturing process and source of DCP (Group, 2015). It is an expensive product, especially when applied as a dust or slurry to feeds such as silage or straw for passive intake as utilisation is at best, about 50%. Conservatively, DCP has a 30% intake rate when dusted, or spread as a slurry. The P component is about 60-70% available to the cow, and with a low Ca:P ratio, absorption is further limited to less than half the percentage of Ca in DCP.

Dairy Business Centre (DBC) have recognised the need for effective P supplementation due to the deficit created by feeding fodder beet, and ever increasing milk production on a per cow basis. Significant research and consulting with experts in the field of mineral supplementation have resulted in DBC creating a complete, balanced and highly available mineral lick to help rectify the issues associated with fodder beet, without creating further complications.

Areas of focus in formulating the lick (Fodder beet Loose Lick) and its associated licks were to firstly balance the mineral combinations to limit any negative interactions that would detract from optimal absorption, especially of phosphorus. Economy was also an area of major focus so limiting wastage through either inefficient application or luxury excess consumption that you see with molasses lick blocks had to be minimised. This was done by relying on the cows innate craving to satisfy mineral demands by consuming the actual minerals that they require, rather than sweeteners such as molasses. By doing this, it satisfied a third focus for the lick, and that was to be able to provide enough mineral to meet requirements as it is in a loose, powdered form.

With blocks, either salt or molasses, intake rates are too slow to provide enough mineral to each cow. They must stand and lick for a long time to meet mineral requirements, this results in either; cows not having enough time at the block to get enough minerals, or the farmer putting many more blocks in the paddock so that all cows can spend the time licking. In addition, consumption is encouraged by sweeteners so satisfaction of mineral requirement is not guaranteed and excess consumption is a possibility too.

In addition, the economy focus was furthered by waterproofing the lick. By adding a non-toxic, biodegradable waterproofing agent, the lick can be rained on without turning it to a slurry, creating a crust, or wasting any of the product. Instead water pools on the top of the lick, and can be either drunk by the stock, or tipped off, leaving the product dry underneath.

It is recommended for Fodder Beet Loose Lick to be made available 2 weeks prior to fodder beet being introduced to the diet and offered throughout any fodder beet supplementation. If fodder beet is made a significant part of the winter diet, then best practice is to make the lick available through until mating. The exception is 2 weeks prior to calving, where it should be removed from the diet due to the Ca content.

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