TechNote 10

Response to supplements

IN THIS TECHNOTE

A key driver of profitable farm businesses is the ability to balance feed supply and feed demand. This requires a focus on pasture management and being able to incorporate any necessary supplementary feed (supplements) into a pasture-based system profitably.

Profitable use of supplements requires consideration of the following:

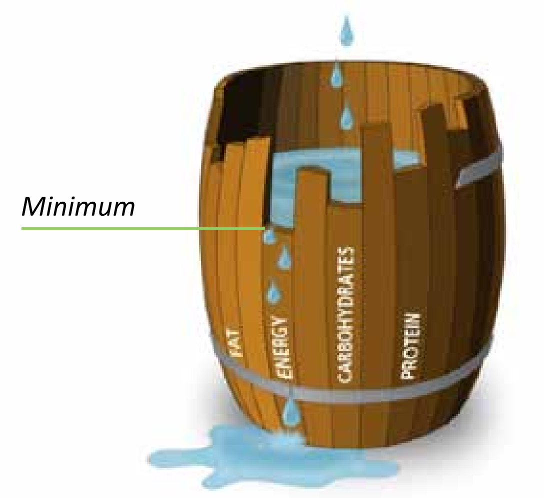
- determine the limiting nutrient,
- identify the appropriate supplement (cost and composition),
- calculate the response to the supplement,
- determine the total cost of feeding the supplement.

10.1 Determine the limiting nutrient

When deciding if cows need more of a particular nutrient in their diet, the first step is to determine which nutrient(s) are limiting performance. This can be done using Liebig's law of the minimum, with the analogy of a barrel with staves of unequal length (Figure 1). The ability of the barrel to hold water is limited by the shortest stave. It does not matter how much longer the other staves are, the barrel will still not hold more water. This analogy can be applied to a cow's milk production. Milk production is limited by the nutrient that is in shortest supply, compared with the requirement. Increasing the supply of non-limiting nutrients will not increase milk production. For example, if milk production is limited by energy, increasing the protein content of the diet will not increase milk production unless energy is increased (Figure 1).

In support of this, production from cows being fed a total mixed ration (TMR) was compared with cows grazing pasture. A biological model (Cornell Net Carbohydrate and Protein System; CNCPS) was used to determine that approximately 90% of the difference in milk production (44.1 kg vs 29.6 kg milk/cow/day) was due to energy available for milk production (i.e. increased feed availability,greater dry matter (DM) feeds, and reduced animal activity in a TMR system) and only 10% of the difference was due to the nutritional composition of the diet. Therefore, if cows are eating a diet of good quality pasture, the supply of protein, carbohydrate, fibre and fat will be more than adequate to meet requirements, and energy (MJ ME) is most likely the limiting factor.

Figure 1. Liebig's law of the minimum.



A good rule of thumb is that supplementary feeds should only be considered:

- when pasture growth is less than herd feed demand,
- to achieve pasture management targets (e.g. pre-grazing leaf stage, length of grazing round and/or pasture residuals),
- if the weather does not permit good pasture utilisation,
- if pasture quality is compromised and does not meet the nutritional requirements of the herd (e.g. low protein in summer pastures).

In all these situations, the economics of feeding supplements must be considered and if focusing on milk production, supplement they should only be used when the revenue generated from the response to the supplement is greater than the total cost of feeding the supplement.

10.2 Identify the appropriate supplement

If supplements are incorporated into a system to fill an energy deficit, they should be of good quality (> 10 MJ ME) and purchased on a cost/MJ ME basis. Consideration needs to be given to the composition of the supplement and any risks associated with introduction into a pasture-based system (e.g. high sugar or starch feeds must be managed by slow integration to avoid rumen acidosis).

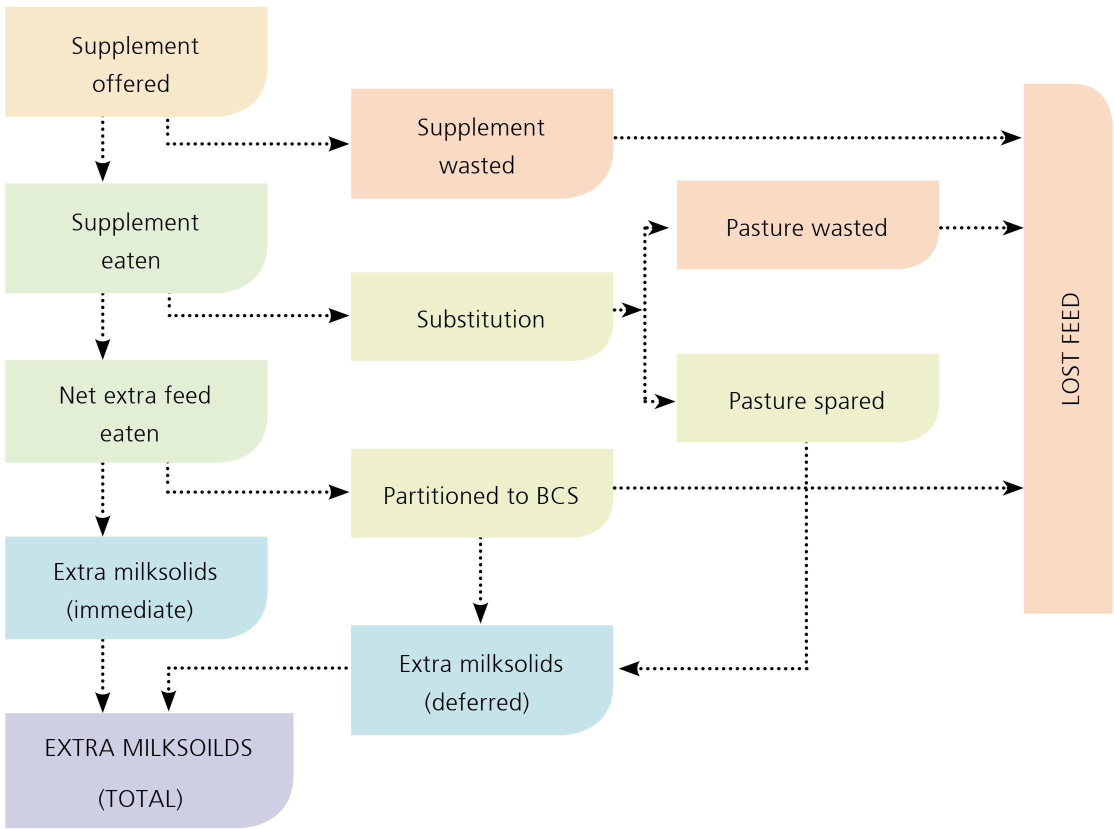
If supplements are being used to fill a protein deficit, consideration must be given to the type of protein in the feed. Generally, if low protein feeds are being fed (e.g. summer pasture and maize silage), and protein is limiting production, a response will only be generated if undegradable dietary protein (bypass protein) is added. However, consideration must be given to the cost of this supplement.

For more details see TechNotes 3: Whats in a feed, 4: Feed composition and characteristics, 5: Carbohydrate metabolism, 6: Fat metabolism, 7: Protein metabolism, and 8: Fibre metabolism.

10.3 Calculate the milksolids response to supplements

When supplements are incorporated into a pasture-based system there is the potential for increased total intake and higher production. However, the actual milksolids response is variable and often less than expected. This is because several factors affect the milksolids response to supplements (Figure 2).

Figure 2. *Key factors that affect the total milksolids response to supplementary feeds in a pasture-based system.*



From a physiological perspective, the dairy cow requires 70 - 80 MJ ME to synthesize 1 kg MS (3.5% protein and 4.5% fat). This means 1kg DM should provide enough energy to produce 140-150g MS. However, this is the maximum possible physiological response and assumes that all the metabolisable energy from the supplementary feed is converted into milksolids, which is not the case in a grazing situation (Figure 2). The total milksolids response to a supplement includes both the immediate and the deferred response and this is influenced by wastage, substitution and energy partitioning.

10.3.1 Wastage

When supplementary feeds are offered to grazing cows there is always some wastage. Wastage occurs during the transporting and feeding out process, and incomplete eating of the feeds. The amount of wastage varies depending on the feed, the feeding method, the infrastructure, and the management practices of the operator(s).

Some good rules of thumb to manage wastage are:

- 5% for automated (in-shed) feeding,
- 10% for feed offered on a feed pad,
- 15% for feed offered from trailers in the paddock,
- 20% for feed fed out in the paddock in good (dry) conditions, and
- 40% for feed fed out in the paddock in poor (wet) conditions.

Feed wastage, or feed utilisation, needs to be taken into account when calculating the amount of supplementary feed that the cow has eaten (Table 1).

Table 1. *Sample calculation of the amount of feed utilised or eaten.*

For example: 0.8 tonne wet weight PKE fed in trailers to a herd of 360 cows

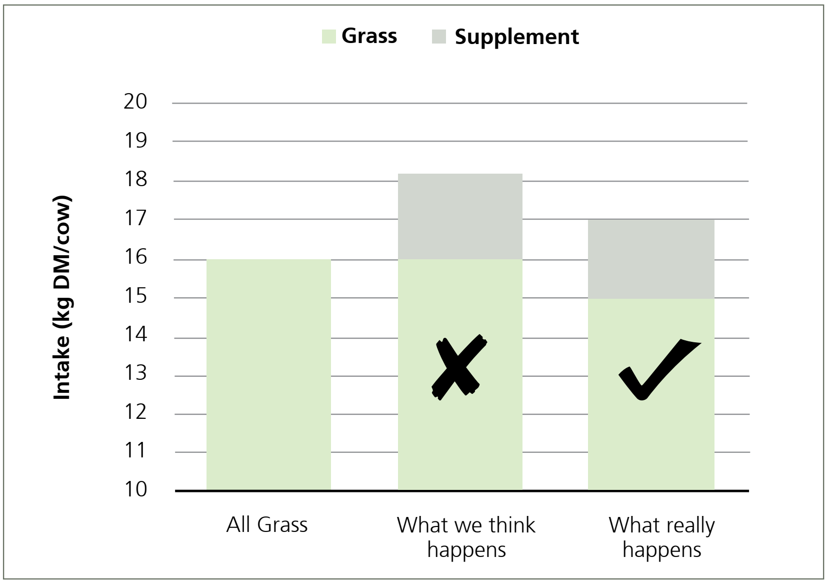
tonne wet weight fed to herd	x	DM%	x	1000	=	kg DM fed/herd
0.8	**x**	0.90 (90%)	**x**	1000	=	720
kg DM fed/herd	**÷**	**number of cows**	**=**	**kg DM fed/cow**		
720	÷	360	=	2		
kg DM fed/cow	**x**	**utilisation***	**=**	**kg DM eaten/cow**		
2	x	0.85 (85%)	=	1.7		

**Utilisation (%) = 100 – wastage (%)*

10.3.2 Substitution

Typically, the factor that has the greatest impact on the milksolids response when feeding supplements is the reduction in pasture intake. This is known as substitution (Figure 3).

Figure 3. *Effect of substitution on total intake (kg DM eaten/cow).*



Substitution is a physiological phenomenon and there is always some substitution when grazing cows eat supplementary feeds. On average, cows will graze for 12 minutes less, for every 1 kg DM of supplementary feed that is introduced into the system.

Substitution simply means that when supplements are fed, the increase in total DM and energy intake is less than the amount of supplement offered (Figure 3).

Although some substitution always exists, the rate of substitution depends on various feed and animal factors including:

- pasture residuals, type and quality,
- supplement intake, type and quality,
- cow body condition score and genetics, and
- season (spring vs. summer vs. autumn).

A calculation (derived by Stockdale, 2000) helps explain approximately 50% of the variation in substitution and considers pasture intake and species, season, and supplement type and amount.

Substitution =

-0.26 + 0.17 (PI) + 0.12 (Spp) + 0.08 (Ssn) + 0.03 (SI) – 0.04 (Smix)

- PI = unsupplemented pasture intake (kg DM per 100 kg LWT).
- Spp= major pasture species in diet (1 = grass; 0 = white clover).
- Ssn = season (1 = spring; 0 = summer; 1 = autumn).
- SI = supplement intake/cow per day (kg DM).
- Smix = type of supplement (1 = concentrate; 0 = forage/concentrate mix; -1 = hay and maize silage).

Positive and negative effects of substitution

Substitution can have either positive or negative effects on the farm system. Negative effects of substitution include feed (energy) being lost due to good quality, high energy pasture that could have been eaten being left behind in the paddock. These leaves will die and energy is wasted.

In contrast, positive effects of substitution include the extra pasture that can be grown, or spared, when supplements are used to meet target residuals or round length. This pasture can be eaten later and contributes to the deferred milksolids response (Figures 2 and 4).

Figure 4. *Positive and negative effects of substitution.*

+	–
Pasture is spared or more is grown	Pasture is not eaten and wasted
Extend round length	High grazing residuals
Achieve target residuals	Reduced yield and quality

Pasture intake residuals

One of the main determinants of substitution is how hungry the cow is (i.e. their pasture intake) and this is generally reflected by the post grazing residuals. The hungrier the cow, the lower the residuals, thus the lower the substitution rate and, consequently, the greater the milksolids response.

Pasture type and quality

At a given level of pasture intake there is a greater level of substitution when the pasture consists of rye grass dominant species compared with clover dominant species.

Within the same species of pasture, the greater the pasture quality (digestibility), the greater the rate of substitution when supplements are fed.

Supplement intake

As the amount of supplementary feed eaten increases, the level of substitution increases, primarily due to satiety signals that tell the cow she is not as hungry and not prepared to spend extra energy harvesting pasture.

Supplement type and quality

Substitution is about 10% greater with a forage (e.g. cereal silage) compared with a concentrate (e.g. cereal grain), and is greater with highly digestible concentrates (e.g. cereal grains) compared with whole grains or protein-based supplements.

Substitution is greater with starch-based compared with fibre-based concentrates, (e.g. maize grain compared with pakm kernel extract; PKE), most probably due to the greater production of satiety signals and hormones (e.g. insulin) from high starch feeds.

Cow body condition score and genetics

Cow factors, such as body condition score (which reflects energy state) or genetics (breeding worth), can affect the level of substitution. If offered the same amount of supplementary feed a cow with a lower body condition score will have a lower level of substitution, compared with a cow of greater body condition score. This is because she will have a greater drive to eat.

Higher producing cows (higher breeding worth) tend to have a lower substitution rate when fed supplementary feeds and thus a greater milksolids response. The greater response is predominantly due to differences in the immediate milk response, as these cows will partition more energy to milk production at the expense of body reserves. However, these cows generally require more feed later in the season (late lactation/dry period) to gain body condition, so the difference between whole season (total milksolids) response is not as great.

Season

Substitution is greatest in spring and lowest in autumn. As a rule of thumb for every kg DM supplementary feed offered, substitution is 0.1 kg DM greater in spring than in summer, and 0.1 kg DM greater in summer than autumn. For example, if the substitution rate is 50% in spring (i.e. for every extra 1 kg DM supplement eaten, 0.5 kg DM pasture would be left behind), in summer the substitution rate would be 40% (0.4 kg DM pasture left behind) and in autumn 30% (0.3 kg DM pasture not eaten).

10.3.3 Energy partitioning

The partitioning of energy (between milk production and body reserves) depends on several factors:

Energy status of the cow

- more energy is partitioned to body reserves in thinner cows

Genetics of the cows

- more energy is partitioned to body reserves in lower producing cows

Amount of supplement fed

- more energy is partitioned to body reserves as supplement amount increases

Body condition gained while supplements are being fed is taken into account through the deferred milksolids response; however, the amount of energy supplied when body reserves are mobilised is less than the energy required to store these. For example, a lactating cow requires 50 MJ ME to store one kg LWT; however, mobilising one kg LWT only supplies the cow with 37 MJ ME. The drop in energy is due to energy lost in the process of mobilising and converting the stored fat (see example calculation below).

Example:
If a lactating cow gains 0.2 BCS units (6.6 kg LWT) this requires approximately 330 MJ ME (6.6 kg LWT x 50 MJ ME/kg LWT) or 27.5 kg DM of a 12 MJ ME feed.

When this body condition is mobilised later in lactation it only contributes 244 MJ ME (6.6 kg LWT x 37 MJ ME/kg LWT) or 20.5 kg DM of a 12 MJ ME feed.

For more details see TechNote 16: Understand energy requirements.

10.3.4 Total milksolids response

The total milksolids response from the supplement is the sum of the immediate milksolids response (extra milksolids produced while the cows are receiving the supplement) and the deferred milksolids response (extra milksolids produced later due to pasture spared/grown and body condition gained while the supplements were being fed).

The total milksolids response from feeding supplements, and the revenue generated depends on the milksolids yield and composition.

10.3.5 Milksolids composition

The composition of the immediate milksolids response is affected by the type of supplement fed.

Feeds high in starch, such as barley and maize grain, increase the production of milk protein more than milk fat, while feeds high in fat or fibre, such as PKE, soyhulls and broll, increase the production of milk fat more than milk protein. Feeds high in sugar tend to increase milk fat; however, this depends on the base diet.

The deferred milksolids response is not affected by the type of supplement fed.

The change in milk composition, in particular the production of protein and fat, should be considered when calculating the milk revenue from feeding supplements as some milk buyers differentiate payment between milk protein and fat.

10.4 Determine the economics of feeding supplements

To determine the cost of feeding supplements, wet weight (kg) must first be converted to dry matter (kg DM) to give a cost/kg DM fed (Table 2).

Next, the costs of feeding the supplement need to be included. This depends on the method of feeding (e.g. in-shed versus trailer in the paddock). This is often forgotten and many people to 'margin over feed' as a way of accounting for the cost of supplementary feed. However, this assumes that the only cost of feeding is the feed itself and ignores associated costs such as fuel, repairs and maintenance and labour. International and New Zealand datasets indicate the total costs associated with the use of supplements can be 1.3 to 1.7 times the purchase cost of the feed. These total costs include:

- actual price paid for the supplement delivered on farm,
- associated costs such as, fuel, labour, repairs and maintenance,
- non-associated costs, such as fertiliser,

The associated costs equate to between 5 – 10% of the actual cost of the feed, depending on the method of feeding out. For example, it may cost an extra 2.5c/kg DM to feed concentrate in the shed, whereas this may increase to 3.0c/kg to feed PKE from a trailer in the paddock, 4.5 c/kg DM for feeding silage on a feed pad, and closer to 6.0c/kg DM for silage fed in the paddock.

Two datasets (from the UK and Ireland) indicate that the non-associated costs that increased with supplementary feeding included virtually every cost (variable and fixed) on the farm. The UK data highlighted an increase in total farm costs of £1.62 for every £1 spent on imported feeds (i.e. forages and concentrate feeds). Consistent with this, data from Irish farms highlighted that, on average, the total cost of production increased £1.52 for every £1 spent on purchased feed.

DairyNZ Dairybase data indicate the total cost of feeding supplements ranges from 1.3 to 1.8 times the cost of purchasing the feed, depending on the region. Therefore, it can be assumed that the total cost of feeding supplements is at least 1.3 times the cost of purchasing the feed itself and this must be considered in the budget.

Table 2. *Calculations of the cost of supplements (c/kg DM and c/MJ ME fed).*

Example: PKE delivered for $245/tonne, fed in trailers and 11 MJ ME

$/tonne wet weight	÷	DM %	÷	1000	=	c/kg DM fed
$245	**÷**	**0.90 (90%)**	**÷**	**1000**	**=**	**$0.27**

c/kg DM	+	additional costs*	=	c/kg DM fed	÷	MJ ME/kg DM	=	c/MJ ME fed
27	**+**	**8.1**	**=**	**35**	**÷**	**11**	**=**	**3.2**

*assumes additional costs of 30%.

10.4.1. Supplementary feeding decisions

Decisions to purchase and feed supplements need to be made at both a strategic and tactical level.

Strategic decisions

The decision to incorporate supplements into a farm system should involve an annual feed budget and be based on various factors including:

- stocking rate,
- pasture grown, and
- system goals, e.g. spring/autumn calving or milking frequency.

When making strategic decisions, it is important to make sure the system is resilient to outside influences where possible and to remember that the average annual response to supplementary feeds on-farm is 55 – 80 g MS/kg DM. It is also advisable to 'ask why before you buy'.

The DairyNZ Spring and Summer Feeding Check highlights some of the factors to consider, information to collect and questions to ask when determining which (and how much) supplement(s) to buy. This resource can be downloaded from dairynz.co.nz/publications/feed/spring-feeding-check.

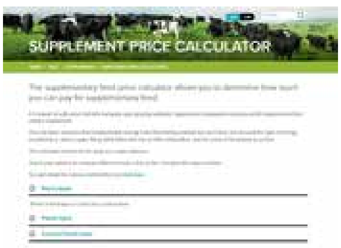
Tactical decisions

After determining the limiting nutrient, identifying the best supplement (composition, characteristics, response and cost) the key question to ask is "Should supplements be fed today and if so, how much should be fed?"

To answer this question, the following factors, need to be considered:

- pasture residuals,
- average pasture cover,
- round length,
- does the revenue outweigh the total cost of the supplement (including additional costs)?

The following resources provides a simple framework to estimate the costs and revenue of feeding supplements in a grazing system at different stages of lactation.



'DairyNZ Supplement Price Calculator' - an online tool that predicts the milksolids response and profitability of feeding different supplements in various pasture-based scenarios.

www.dairynz.co.nz/feed/feed-management-tools/supplement-price-calculator/

DairyNZ – Spring/Summer Feeding Check - based on estimates from the Supplement Price Calculator and encourages the use of a weekly feed management check to monitor feed management both in the paddock and the use of supplements at various times of the season.

http://www.dairynz.co.nz/publications/feed/

10.6 Further reading

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