Supplements: Where do those nutrients go?

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Introduction

Supplementary feeds play an essential role in balancing the feed budget for almost all dairy businesses. Home conserved forages may be the only supplements for properties with low stocking rates. Conversely, high stocked properties place a greater reliance on purchased forages, grains and / or by-products. Irrespective of the system, the common goal is to optimise the conversion of supplements to milksolids (MS).

The MS production potential from supplements is variable, being influenced not only by characteristics of the supplement but also by pasture quality and quantity, feeding out facilities, environmental conditions and animal-associated factors. This paper explores reasons for variable responses to a range of different supplements, and identifies ways to optimise return on investment for both home grown and purchased in feeds.

Supplements: Why don't those nutrients all end up in the vat?

Wouldn't it be fantastic if every single megajoule of metabolisable energy (MJME) or kilogram of crude protein (CP) ended up converted directly to MS? Life would be simple and profitability would lift for every New Zealand dairy business.

"Where are those milksolids?"

Many businesses monitor the MS response to supplements, both as a short term (or immediate) response to supplementation (what's in the vat today from a supplement fed yesterday) or increasingly, reviewing the annual MS yield produced from a combination of pasture and purchased supplements. Either way, we seek reassurance that supplements are paying their way as an effective and profitable means to lift MS production. If the numbers do not stack up, the challenge is to identify why supplements are not supporting expected MS responses.

A multitude of reasons outlined in Figure 1 account for the failure by supplements to deliver an expected MS response.

Figure 1**:** The potential fate of supplemented nutrients offered on farm

Investigating a sub-optimal MS response to supplements

When we feed out supplements we expect a beneficial response, either as more MS and / or cow condition benefits. Typically we'll look for an immediate response as more MS in the vat – a relatively fast and easy outcome to monitor, which is typically in the vicinity of 40 to 80 grams of MS per kgDM of supplement.

Longer term benefits from supplementary feeding are improved cow body condition. Better cow body condition can deliver more MS later in the season, more MS the following lactation, and improved reproductive performance. These longer term benefits can be difficult to define when compared with the more immediate 'in the vat' responses, but for most herds, the benefits of improved cow condition are often the more important and profitable outcomes from the feeding of supplements.

What do we do when there's an apparent lack of MS response to supplements offered on a day to day basis? What happens when you're feeding e.g. 4.0 kg dry matter (DM) per cow per day of a feed such as pasture silage, and MS production doesn't appear different from last week, when you *weren't* feeding out silage? What might be happening? Or, worse, you're feeding out silage and MS production is *lower* than you'd expect it to be?

The approach to dealing with a sub-optimal MS response will vary, depending on if it's a short term issue – where are the MS TODAY? Or, if it's a longer term issue as part of an annual review of business performance that seeks to define the return on investment in the purchase of supplements.

Figure 2: An investigative approach to deciding why you're not seeing an expected MS response to a supplement offered to cows (both short and longer term responses).

Take a practical approach when investigating sub-optimal MS responses to supplements. Most cases of poor conversion of supplements to MS are caused by the same basic challenges that are

typically identified in the field by examining the supplements, feed out facilities, the cows and the pastures.

With silages comprising the majority of supplements on farm, it's appropriate to start discussions of poor responses to supplements with a look at the challenges of harvesting and feeding out silages. It's common when investigating a sub-optimal MS production issue to find that one or more attributes of a silage are contributing to the problem.

Is the DM tonnage of silage in the stack or pit actually <u>all</u> there?

Most South Island dairy businesses purchase standing forage for ensiling, either as pasture, lucerne, cereal or maize silage yet few people account for nutrient losses during the ensiling process. These losses are a common reason for a poorer than expected MS response to a given tonnage of purchased forage. It is incorrect to presume that every kilogram of dry matter (DM) purchased as standing or as chopped fresh forage for ensiling will either;

- Ultimately be presented to the cow as an ensiled feed *or*
- That the final ensiled feed will have the same nutritive value as the fresh forage.

ALL silage stacks, irrespective of type of forage, method of ensiling or additives will undergo some DM losses in the stack. The reasons for DM loss and the extent of losses in the stack depend on the characteristics of the ensiled forage and how it is handled from the point of mowing to covering (Figure 3).

When running an annual feed budget, ALWAYS account for loss of DM during ensiling or the tonnage of fresh forage purchased is unlikely to realise the expected animal performance. For example, if you buy 100 T DM of standing pasture for silage, expect that, by the end of the ensiling process (when you open the stack) that you'll only have at best, 85 to 90 T DM to feed out, the rest will be lost as outlined below.

Figure 3: Potential losses of DM for chopped forages in pit storage facilities (from 'Successful Silage"; NSW Agriculture and Dairy Research and Development Corporation 2003)

(a) Type of crop / silage

A very well made stack or pit of maize silage is the 'gold standard' as an example of a silage that undergoes minimal DM losses during ensiling. Maize is a relatively easy crop to ensile because of its low buffering capacity (low resistance to drop in pH) and is typically chopped short, improving the compaction potential of a stack or pit. Losses for a well made maize silage are typically less than 10% of DM. Conversely, a very wet grass silage, e.g. less than 20% DM is prone to considerable losses due to loss of DM as effluent, fermentation losses and through spoilage. Losses in some cases will exceed 30% - e.g. a 100T DM stack may be left with only 70 T DM at the end of the ensiling process.

(b) Wilting

Wilting is necessary for lucerne, pasture and green chop cereal silage, but can result in DM losses of between 2-3 % (lightly wilted crop) to 8% for an over-wilted, over dry crop. Losses are caused by the plant continuing to respire, a process which may consume considerable DM. Best practice for pit or stack pasture silage it to target a DM% of no more than 28 to 30% to minimise wilting DM losses.

Crops too wet

Effluent losses are inversely related to the DM % of the chopped forage (Figure 3) and are of relevance only to pasture, lucerne and green chop cereal silage. Direct chopped whole crop cereal and maize silages have a higher DM% and DM losses as effluent are extremely rare. For poorly wilted, very wet pasture silages, more than 5% of the DM ensiled can be lost as effluent. E.g. if you've ensiled 100T DM of pasture silage at 18% DM, you could lose 5 T DM as effluent – a costly loss of DM, before considering the other problems created by a substantial volume of effluent runoff.

To minimise the risk of effluent losses, target a DM % of between 28 and 30%. When drying conditions are unfavourable and you are unlikely to dry a crop to 30% DM, consider harvesting at lower kgDM covers / ha (allowing a faster wilting rate for a less bulky crop), mow after the dew is off, consider mower conditioning and undertake more tedding.

Figure 4: Potential losses of DM as effluent when pasture silage is ensiled too wet

Crops too dry

Whilst not a common problem for South Island pasture or lucerne silages, overdrying may sometimes occur on hot Canterbury Nor' West days and /or when contractor availability challenges the timeliness of the harvesting process. Field losses (loss of leaf especially, during tedding and raking) are the main source of DM losses. A prolonged fermentation phase may cause further DM losses due to the silage taking too long to reach a final stable pH. During this extended phase, microbes in the stack use up too many nutrients during respiration = a net loss of DM and loss of forage quality.

Always allow for some DM loss during ensiling, as little as 10% of DM for a well made maize silage and as high as 30% for a poorly made stack of grass or lucerne silage.

Check the wet weight of supplement offered per day

A silage wagon with scales remains the gold standard. Any large dairy business that is feeding out silage must know the daily feed out rates for silage. This reduces inconsistencies created by the different loading techniques by various staff members and assists with the monitoring of silage inventories when the tractor driver logs the daily cumulative tonnage of silage fed out. It is common for wagons to not have scales and for many dairy businesses to have no idea as to the daily feed out rate of silages and other supplements. This is a liability for any business.

For in-shed feeding systems delivering dry feeds (cereal grains, by-products such as PKE, tapioca) or wet feeds such as molasses, check the actual weight delivered by the system on

a weekly basis. Discrepancies are not uncommon, especially for older systems and are a common cause of apparent failure by cows to respond to a supplement. For herringbone systems, check the weights from several of the feeders as variance along the row can be common.

Know the dry matter % of a silage or other purchased feeds

Multiplying the wet weight in a silage wagon x the DM% of the silage as assessed by a feed testing laboratory gives a more appropriate indication of tonnage of DM than simple (and often inaccurate) estimates of DM% based on a 'squeeze' test on silage. Collecting multiple core samples from a stack or pit and submitting these to a feed testing laboratory is the standard approach, and also allows you to analyse the sample for quality. Home microwave methods for DM analysis are inappropriate for silage samples because organic acids are lost from the sample during heating and will provide an incorrect DM%. A laboratory assessment of DM% for ensiled material remains the preferred method because the lab will apply a correction factor for the loss of organic acids during heating.

Knowing the DM% of the silage sample enables you to multiply the wet tonnage of silage x the DM% to more accurately calculate the tonnage of silage DM offered to cows. Note that this is on the assumption that the silage wagon has scales and you're not relying simply on cubic metres of silage into a wagon.

For supplements other than silage, knowing the DM % is potentially just as important as for silage. E.g. if you have two lines of barley grain, one is 85% DM (15% moisture) and the other is 88% DM (12% moisture), for a cow offered 3.0 kg per head per day, there is 90g DM per head (or about 1.125 MJME) per day difference in DM offered per cow. Milksolids responses to each line of grain will vary, accordingly. Note that the amount of DM purchased per tonne of grain will also vary with grain DM%. If both lines of barley are landing at $400 per tonne, the 85% DM line is costing you $470 per tonne of DM. The 88% DM line is costing you only $454 per tonne DM.

Review the numbers of cows in a mob

If a fixed amount of supplement is fed out based on the presumption that there are 400 cows present, but there are actually 450 cows present, not surprisingly the MS production won't meet expectations if all cows are underfed. This is a common cause of MS responses to supplements failing to meet expectations, and is especially common in the spring when mob sizes are continually changing with cows drafted across from the colostrum mob.

This is a basic concept to identify, yet remains a common cause of failure by cows to respond to supplemental feeding.

Have you allowed for loss of supplemental dry matter at feed-out?

Wastage of supplements at feed out is extremely variable between feeds and feeding systems. For feed budget planning purposes, and to help when investigating an apparent absence of MS or cow condition score response to supplements, an appropriate loss of supplements at feed-out must be factored in during your annual planning process.

Contributing factors to wastage or losses of supplements at feed out include:

(a) Aerobic spoilage of silage at feed out – at the stack and in the paddock

For silages, some DM losses occur at the face of a stack or pit before the silage is fed out, and are caused by 'aerobic spoilage'. When silage is exposed to air, yeasts, moulds and bacteria grow and use up valuable nutrients and DM. You'll notice this as heating of the silage on the face. Aerobic stability depends on silage type, DM%, density of the silage, frequency and extent of removal of silage from the face, temperatures at feed-out, size of the face, feed out technique (bucket, grab or shear grab) and additives in the silage. Loss of DM and deterioration of quality can be considerable, particularly for poorly made maize silage or cereal silages.

Aerobically spoiled silages will be refused / wasted by cattle at feed-out, further contributing to DM loss at feed out.

Preventing aerobic spoilage requires best-practice ensiling techniques, 'top shelf' feed out techniques (keeping a tidy face and minimising aeration of the face with the bucket or grab), targeting a narrow silage stack or pit face and considering the use of alternative silage inoculants that may improve the aerobic stability of high risk stacks.

(b) Wastage of supplements at feed-out

Rates of wastage vary and are influenced by many factors. Examples might include:

In-Shed Feeding systems

- Molasses– almost 100% utilisation / 0% wastage
- Rolled barley– typically greater than 95% utilisation / less than 5% wastage

Feed pads

Supplement utilisation rates of 95 – 100% can be achieved on feed pads with the exception of the following circumstances:

- Poor quality silage based rations causing build up of uneaten feed and resulting wastage

- Other factors that limit DM intakes including inadequate stock water, cow discomfort (e.g. due to overcrowding, slippery conditions underfoot), disease that limits DM intakes e.g. sub clinical rumen acidosis or milk fever
- Poor design of troughs that reduce cow comfort, e.g. too high, too narrow (competition of cows across trough from one another), cows climbing in and dunging on the feed
- Cow behavioural issues contributing to greater wastage, e.g. bothered by flies, throwing feed over backs, overcrowded cows with more bullying of cows = more spillage of feed on the pad
- Unpalatable additives e.g. urea that cows have not previously been exposed to

Feeding out in the paddock

Although most would agree that this isn't ideal, paddock feeding remains the most common way for supplementation of South Island dairy cattle. Love or loathe it, considerable losses of DM must be accounted for when trying to balance a feed budget.

"There is no such thing as 100% utilisation of a supplement fed in a paddock".

Losses are variable and reflect type and quality of a supplement (especially the tastiness of a feed), fineness and texture of a supplement, stock class (milker or dry stock), conditions under foot (wet or dry), quantity of feed on offer, including pasture on offer and rotation length and feed out technique – typically the area over which the supplement is fed out. Remarkably, there are no objectively determined figures that have demonstrated actual wastage rates of feeds fed out in paddocks for different feeds under various feed out conditions.

(c) Minimising wastage in the paddock

With so many factors and constraints involved, approaches to the resolution of feed wastage will vary with the situation. At best, you should allow for at least 10% wastage of any feed in the paddock. Wastage may approach 50% or more for e.g. fine chopped pasture silage under very wet conditions on the West Coast.

For finely textured feeds, e.g. Palm Kernel extract, paddock feeding is unacceptable due to wastage problems. Ideally these finely textured feeds should not be fed on the ground in the paddock at all.

Make sure <u>any</u> feeds are presented to cows in a palatable form, particularly silages which if affected by aerobic spoilage will be poorly accepted by cattle and more prone to wastage.

Hungry cows are more likely to utilise supplements well than cattle full of pasture, provided access to the supplements is limited to help prevent hungry cattle trampling and dunging on the supplement. E.g. run a supplement under a wire but on top of the next clean

break of pasture – such that the supplement is up off the ground from the eaten out break (less contamination with mud and dung). Wait until all cows are onto the eaten out break after milking then let them across onto the new break and supplement. If the supplement is sufficiently tasty, this allows all cattle access to the supplement (stopping dominant cattle from bingeing) and increases the likelihood of better utilisation. Alternatively, feed out the supplement under the wire on the next pasture break, and allow cows to eat the supplement by reaching under the wire before letting them across onto the new pasture break.

Irrespective of best practice technique at feed out, we must accept that some of a paddock-fed supplement will be wasted by feeding on the ground and will be unavailable for MS production. Factor this into both your short term expectations for MS response and your annual planning.

(d) Loss of other supplements at feed-out

Poor feed conversion efficiencies from other types of supplements tend to reflect the characteristics and / or weaknesses of individual feeds.

Poorly rolled or hammered cereal grains are a common source of feed wastage, due to the inappropriate loss of unprocessed grain in the dung. Note that for lines of grain that contain many 'skinny' grains, we need to accept some degree of wastage because not every skinny grain can be successfully rolled without increasing the risk of rumen acidosis. Cows will digest unprocessed grains to some extent, but losses are likely to exceed 30% or more, particularly when rumen outflow rate is rapid (as is the case when cows graze high quality pasture). Note that typically oats don't need processing to be utilised by cattle, but that a light roll will potentially enhance utilisation particularly when rumen outflow rates are rapid for pasture-fed cattle.

For over-dry whole crop cereal silages, loss of grain on the ground and in the dung of cows is another common form of feed wastage. 'On paper' the feed test of the whole crop silage may look acceptable, but what ends up in the cow can be a very different outcome. This is a difficult problem to resolve once the silage is in the stack and is best prevented by harvesting whole crop cereal silage at a target of 35-36% DM when grains tend to stay in the head well and are soft enough to be digested by the cow. Over dry whole crop cereal silage is best fed to dry cows who are more likely to try to pick up whole grain (if the ground is dry) and with slower rumen outflow rates dry cows are more likely to successfully digest some but not all of the whole grains. Dry matter losses will still be considerable. The adeptness by cattle at picking up whole grains will never equal that of sheep.

Are you wasting pasture when you are feeding supplements? (Substitution)

Substitution is defined as the decrease in kgDM of pasture eaten for every kgDM of supplement eaten. Substitution is a complex concept, because it is sometimes viewed negatively (if pasture is substituted and wasted in the paddock) but often positively – if pasture is 'spared' from being eaten such that pasture covers can be built up quickly e.g. to build pasture covers heading into the winter.

Substitution is ranked on a scale of 0 to 1. A supplement with a **score of 0** means if a cow is offered 1.0 kgDM of a supplement, she will continue eat her full quota of pasture. A supplement with a **score of 1.0** means that for every 1.0 kgDM of supplement, a cow will eat 1.0 kgDM LESS of pasture. A reduction in pasture intake caused by supplementation is often subsequent to shorter grazing times (cows sit down with their appetites satisfied, earlier). Starchy supplements (cereal grains, tapioca, hominy or other starch by-products) can cause a low rumen pH and depress numbers of fibre digesting bacteria which may slow the digestion of fibre, further reducing the intake of pasture.

The ideal outcome for supplementation is when substitution is less than 1.0 – that is, when cows consume their supplements but also continue to utilise pasture well such that total daily DM intake is increased.

Substitution is commonly (and often rightly) blamed for the apparent absence of MS response to a supplement. When substitution rates are high (close to 1.0), cows eat the supplement but eat proportionately less pasture = no apparent short term change in MS production. This is a good outcome if pasture covers are low and you're trying to lift covers e.g. heading into the winter. A high substitution rate can be undesirable if pasture covers are already at target levels because there is an increasing risk of pasture wastage unless the surplus is controlled.

As part of a supplementation program, pastures must be monitored with a regular farm walk to watch for the effects of substitution. If covers are lifting in response to the feeding of supplements, management decisions can be made, including

- Reducing supplementation rates
- Changing types of supplement for one that is less likely to cause substitution
- Stopping supplementation all together
- Increasing stocking rate on grazed areas by dropping areas of the milking platform out for silage, cropping or regrassing or bringing non-milking stock onto the milking platform (dry cows, calves or heifers).

Many factors influence substitution and it can be difficult to predict the extent to which cows will substitute pasture due to multiple interactions. Influential factors are summarised in Table 1.

Table 1**:** Feed and management factors that influence substitution rate

Factor	**Low** substitution rate	**High** substitution rate
Pasture allowance	Low pasture allowance	High pasture allowance
Grazing time	Short time on pasture (e.g. in large herds)	Plenty of grazing time
Pasture type	Poor quality pastures	High quality pastures
Type of supplement	Forage (silages) and non-starchy concentrates (e.g. PKE)	Starchy (e.g. cereal grains, tapioca)
Frequency of feeding of supplements	Many times a day	Once a day
Processing of cereal grains	Well processed – just cracked	Overprocessed, fine and dusty
Feeding rate of cereal grains or other starchy feeds	Low feeding rates (usually less than 3 to 4 kg per head per day)	Higher feeding rate (more than 3 to 4 kg per head per day of cereal grains)
Type of starchy feed	Oats, barley, maize grain	Wheat, tapioca, hominy
Level of fat in the diet	Lower fat supplements	Higher fat supplements
Stage of lactation	Late lactation	Early lactation

Note from Table 1, it is unlikely that only one factor will influence substitution– multiple factors will collectively interact to determine final substitution rate.

Negative substitution rates. Occasionally, offering supplements can promote a greater than expected MS response, most often due to a synergistic benefit linked to the feeding of that type of supplement. Whilst less common, examples include molasses offered to cows eating a very poor quality diet – for example, dried off summer pasture of poor quality or very high rates of poor quality silage. Offering a source of palatable physically effective neutral detergent fibre (NDF) to cows that are sub-clinically acidotic can help stabilise rumen pH = an improved appetite such that the fibre source increases total appetite and DM intake.

Consider the effect of substitution rates when investigating apparent absence of short term MS responses to supplementation, particularly from high quality starchy supplements offered to cows on a high quality pasture. Regular monitoring of pasture covers will help identify if substitution is creating an unwanted pasture surplus and allow management decisions to be made accordingly.

What's the feed quality of your supplement? Are your expectations for a MS response appropriate for that supplement?

All dairy businesses need to know and understand the quality attributes of any supplemental feeds on farm. It is difficult if not impossible to accurately predict MS responses to a supplement if you can't quantify the key inputs – including quantity of pasture harvested, amount of supplements purchased in or made at home and the QUALITY of those pastures and supplements.

Milksolids responses to all feeds (pasture and supplements) presented to a cow depends on the quality of the feed. The quality of ALL feed types is variable, even for apparently uniform feeds such as barley grain. Variable feed quality will explain much of the variation in MS response to a feed. Feed testing remains the gold standard that provides you with information you need to predict likely responses to supplementation. Feed quality challenges vary across the different supplements, but are often of greatest relevance for ensiled feeds.

(a) Changes in forage quality during ensiling

What goes into a silage stack rarely comes out looking the same. All types of silages change in quality during the ensiling processes, due to

- Loss of water soluble carbohydrates (WSC) during respiration of the plants both after mowing and during the early stages of ensiling in the stack
- Conversion of WSC to fermentation acids by bacteria in the silage stack.
- Proteolysis (breakdown of plant proteins to less desirable N compounds including ammonia)

General changes in quality: Silage vs. the original fresh forage:

Water soluble carbohydrates (WSC)

Quantities of WSC are lower in silage than in the fresh forage, this can be problematic when WSC levels were very low to start with, e.g. fresh nitrogen boosted ryegrass dominant pasture that's cut during dull overcast weather may contain WSC levels of less than 5% DM.

Neutral Detergent Fibre (NDF)

Forage NDF concentrations increase in ensiled forage due to a relative loss of soluble nutrients during ensiling, leaving proportionately more NDF.

Energy (Megajoules of metabolisable energy; MJME/kgDM)

Overall the quality of the silage expressed as MJME / kgDM is lower than the original forage due to loss of soluble nutrients including WSC and plant proteins.

MJME remains the key driver of potential milk yield from a supplement. In simple terms, MJME is the energy available to the cow for useful things like MS production, maintenance, growth, condition gain or pregnancy needs, AFTER we account for energy losses in the dung, as urinary energy and as methane.

Digestibility is the key influencer of the MJME rating of a feed. Simply, a more digestible feed has a higher MJME. Feeds that are almost entirely broken down in the gut (so that little is lost in the dung) are considered highly digestible. E.g. if a silage sample is 70% digestible, it means 70% is available as energy to the cow and 30% is lost in the dung. A common rule of thumb is that you multiple digestibility x 0.16 to give a MJME rating. For a 70% digestible silage x 0.16 = 11.2 MJME/kgDM.

The higher the digestibility, the higher the MJME and the more MS per kgDM.

If the MJME of a supplement is not as high as you believe, you won't see the expected MS response because more of the poorly digestible part of the feed will be lost in the dung. Never base the probable MS and / or body condition score responses to a silage on a feed test of the FRESH forage or we are likely to be disappointed in response by the cows. Never expect silage quality to equal that of the original fresh forage.

Crude protein (CP)

The CP of silage is usually lower than that of the equivalent fresh forage, particularly if effluent losses were observed. Further, the protein characteristics of ensiled forage will be different to that of fresh forage. Ensiled forage contains fewer true plant proteins, and more non-protein nitrogen (NPN). Nutritionally this means more rumen degradable protein (RDP) and less undegraded dietary protein (UDP) in the silage vs. the same plant material when it was fresh. Extensive breakdown of plant proteins is more common in very wet pasture or lucerne silages and those contaminated with soil. Cattle will often refuse silages that contain high concentrations of NPN, such that wastage of DM occurs at feed out – this should be factored in annual feed budget planning.

Typically the CP rating of a feed is less important than MJME in determining likely MS response to a supplement but WILL moderate the response by cows to various supplements

particularly if protein intake is limiting MS production e.g. for winter milked cows on low protein diets.

Too much CP: For cows on a high quality, high CP pasture, supplementation with high CP feeds may accentuate problems of too much CP in the total diet, and incur an increased cost of detoxification of surplus ammonia through to urea, and excretion of urea in the urine. The net cost of detoxification can reduce the expected MS yield from that feed based simply on MJME calculations alone. Alternatively, cows may produce well in response to additional high CP supplements, but cow body condition is compromised. Typically when high quality protein supplements are included in the diet, it is appropriate to include sufficient energy from another supplement such as molasses or starch sources. Note that in some cases, an additional source of high quality protein supplements may be advantageous for MS yield, but this is typically when the amino acid profile of the rest of the diet is not supporting optimal rumen function or MS production and is of greatest relevance when per cow MS production is well above average industry levels.

Not enough CP: This is typically uncommon in pasture-fed lactating cows, but may occur when pasture quality is poor (through the summer for dry land situations and low rainfall) and when cows are fed higher rates of low CP supplements including whole crop cereal silages, cereal grains and molasses.

Protein quality can be important for higher producing herds and will affect MS response under some situations. Silages that are too dry (e.g. dry whole crop cereal silage) undergo heating during ensiling and the protein can become heat damaged, becoming irreversibly bound to fibre. These may still feed test at apparently acceptable levels of CP but some protein won't be available for productive purposes, including milk protein synthesis. Some supplements starting to appear in the market, including dried distillers grains (DDG) contain protein of poor quality and a proportion of CP in DDG is largely unavailable to the cow.

For higher producing herds, the QUALITY of protein and amino acid nutrition is becoming increasingly important, such that some degree of diet balancing on the basis of amino acid nutrition is required. For most herds with moderate levels of production and a high proportion of the diet as pasture, amino acid nutrition is of lesser importance.

For cows of high genetic merit, offering a high quality protein supplement characterised by a high proportion of UDP (or 'bypass' protein) during early lactation may benefit MS production. Care is needed when offering high quality, high UDP protein supplements together with high quality pasture and inadequate energy intakes because an inappropriate loss of body condition can occur. It is appropriate to complement the feeding of pasture and high quality protein supplements with an additional energy supplement, typically a starch source that helps lift blood sugar levels and aims to minimise loss of body condition.

Starchy feeds and CP: The interaction with MS or partitioning towards liveweight gain

When TOTAL quantities of CP or the quality of protein is limiting in a diet but there is ample intake of energy, cows will gain body condition at the expense of MS production. This is because blood sugar levels are high, but there are insufficient amino acids to support optimal production of milk protein. When CP intake is low, blood sugar is diverted from the udder (and from the manufacture of milk lactose) towards lipogenesis (body fat manufacture) under the influence of increased concentrations of blood insulin and reduced levels of growth hormone. Growth Hormone drives milk production at the expense of body condition score. Conversely, insulin partitions nutrients away from milk and towards weight gain and growth.

Starchy feeds particularly will encourage partitioning of dietary energy towards liveweight gain when total dietary levels of CP are limiting MS production particularly when cows are in late lactation.

If you supplement cows with a high energy feed, particularly those that contain high levels of starch, and don't balance the intake of protein to match the udder's need for high quality amino acids, cows will partition extra energy towards liveweight gain. Other factors will influence the extent to which different cows partition energy away from the udder, including total feeding levels, quality of forage, stage of lactation, genetics of the cow and pregnancy. Typically late in lactation, offering cows starchy, low protein diets will result in gain of body condition at the expense of MS production.

Figure 5: Partitioning of energy and protein between the udder and body condition gain when the diet is well balanced for energy and protein – milksolids production is generally favoured

Figure 6: Partitioning of energy and protein between the udder and body condition gain when the diet contains ample energy but when dietary protein is limiting – body condition gain is generally favoured at the expense of milksolids production

Feeding very high rates of maize silage can cause encourage condition gain in late lactation – a desirable outcome to keep more cows in milk for longer, provided level of MS is sufficient to justify milking and doesn't compromise somatic cell counts. Very high rates of starchy forages or grains can reduce or even prevent loss of condition in early lactation unless the diet is supplemented with high quality pasture or protein supplements. The extent of this effect depends on protein levels and quality both in the supplement and the pasture. For herds south of Oamaru, similar situations to that reported for maize silage may occur with whole crop cereal silage, however whole crop cereal silage typically contains more CP than maize silage. Feeding very high rates of whole crop cereal silage plus low CP cereal grains may occasionally stimulate excessive body condition gain at the expense of MS production.

There are no magic rules of thumbs or guides as to likely CP levels for any of the feeds that will 'switch' cows from MS to condition gain, as this is influenced by other factors including starch in the diet, stage of lactation, cow genetics and quality of CP. Generally because most late season pastures after the autumn rains contain ample high quality CP, CP is not limiting unless considerable quantities of low CP supplements are fed – e.g. over half the diet as whole crop cereal silage, low protein grains and low CP molasses and / or cereal straw. Increasingly, protein meals such as canola meal are being fed together with lower CP silages during early and late lactation to optimise MS responses to other supplements. Canola meal has

a very desirable amino acid profile that can stimulate rumen fermentation when forage quality is poor (e.g. when feeding higher rates of low protein whole crop cereal silages).

Feeding low protein, high energy feeds in late lactation will encourage condition gain at the expense of MS production. This is a common cause of short term concern and frustration as to an absence of or a reduced MS response to supplements HOWEVER this works in our favour when cows would otherwise be dried off due to inadequate body condition for wintering.

The body condition score of cows is an important moderator of likely response by cows to diets with differing levels of energy and protein.

Cow body condition score and response to supplements

Not surprisingly, cows in poor body condition score give less impressive short term MS responses to any type of supplement. Mother nature has a built in survival mechanism for cows in lighter body condition, and these cows will typically favour liveweight gain at the expense of MS production, particularly if the diet contains starch and is marginal in CP levels (e.g. light conditioned cows on low protein diets for winter milk production). Even in early lactation, lightly conditioned cows will partition nutrients towards weight gain at the expense of MS production often very soon after calving if condition score is very low.

Conversely, cows that are over-conditioned in early lactation may not milk well in response to supplementation, due to the appetite-suppressing effects of sub-clinical ketosis. Not a common problem, this is most often seen in over-conditioned autumn calvers, or where carry-over cows are over-conditioned.

Cows calving at a BCS of 5.0 will ensure an optimal response to supplementation in early lactation.

IMPORTANTLY for many seasonal calving herds, extra body condition score in late lactation means cows can milk on for longer and come closer to achieving their genetic potential for a 305 day lactation. **Short term "loss" of MS from starchy low protein feeds in late lactation can be extremely advantageous if cows milk for many weeks longer, even if per cow MS production is relatively low.** For a cow in light body condition score who is dried off early, a short lactation is a liability. For a cow to stay in milk for an extra 30 days x as little as 0.8 kgMS/cow/day = an extra 24 kgMS for that cows lactation.

Genetic potential of cows and responses to supplement

Cows of high genetic potential tend to partition nutrients towards MS production, at the expense of body condition score. This effect is more profound during early lactation but will also be seen in late lactation depending on quality of the diet. When total DM intake is limiting, cows of high genetic potential will lose weight when offered supplements – that is, their apparent conversion of nutrients from supplements to MS appears highly efficient. Conversely, cows of lesser genetic merit will "look after themselves" under conditions of feed shortage and hold or even gain body condition at the expense of MS production.

Many factors contribute to the difference in partitioning of nutrients between cows of high and low genetic merit, including different ratios of the hormones growth hormone to insulin which are higher for cows of high genetic merit. More growth hormone and less insulin supports more partitioning of dietary nutrients towards MS for cows of high genetic merit.

Reproductive failure is an increasingly common problem for cows of high genetic merit due to an inappropriate and excessive loss of body condition during early lactation. Supplementation of high genetic merit cows with high energy feeds is proposed by many as a means to hold body condition before and through mating. Starchy feeds and those with a high fat content such as hydrogenated fatty acid products are more likely to be successful in improving cow condition by lifting levels of blood glucose and cholesterol, respectively. The ultimate success of supplementation for reproductive reasons will depend on total DM intake, the level of supplementation as a proportion of a pasture-based diet and CP levels in the diet. Supplements are less likely to assist with holding cow condition in early lactation if total DMI is sub-optimal, if the supplements comprise only a limited proportion of the diet (e.g. cereal grains at only 0.5 to 1.0 kg/day) or when pasture protein levels are very high = a high 'drive' by cows to product MS due to very high quality amino acids delivered to the udder.

CONCLUSION and WORKING EXAMPLE: "Where have those MS gone from my supplements?

If you are left wondering either on the basis of retrospective analysis, or on a day to day basis where the MS in the vat have gone, there are a multitude of interrelating factors that may be responsible.

(a) *Annual retrospective analysis.* Where the tonnes DM of pasture production per ha is known, and pasture utilisation is accurately assessed, the conversion of tonnes DM / ha of supplements to kg MS / ha can be calculated. The key limitation to this

approach is that we're constrained by error associated with several key inputs, including tonnes of pasture grown and utilised (a figure that is often not well known by most dairy businesses). Nevertheless, the retrospective analysis of efficiency of conversion of tonnes DM of supplement to kgMS is an important process when justifying the considerable expense of supplements for a business.

(b) *Shorter term assessment of MS response to supplements.* This aspect of analysing "where the missing MS are" can be more rewarding, because supplement and pasture management can be manipulated over a short period and potentially alter MS responses. Using the 'quick 'n' dirty calculator for defining where the energy component of feeds may go, energy partitioning between MS production, cow condition score, pregnancy and walking can be explored.

Quick'n'dirty calculation of energy requirements for milking cows

Maintenance requirements:

500kg cow needs 60 MJME / day. Add or subtract 5 MJME / 50kg of liveweight. E.g. 450 kg cow = 55 MJME /day.

Walking: Allow another 1 - 1.5 MJ per 1 km walked each day *(actual figure is not accurately known)*. Hill walking increases energy requirements substantially – over 5 MJME per km walked on a steep hill.

Milksolids production:

Milk test (%)	MJ/kgMS
7.2	69
8.0	68
8.7	66
9.4	65
10.2	64

Weight gain: 32 MJ / kg liveweight (spring pasture) or 35 MJ / kg (autumn pasture)

Weight loss: Each 1 kg of liveweight mobilised 'releases' 25 MJ for milksolids production

Pregnancy:

Weeks before calving	MJ/day
12	8
8	14
4	25
0	43

A working example:

Energy requirements / day for a 450 kg cow on 1st May, due to calve 1st August. Producing 1.4 kgMS / day with a 9.4% milk test, and trying to gain 0.25 kg liveweight / day. She walks 6 km per day.

Maintenance	=	55 MJ
Walking	=	6 MJ
MS	=	91 MJ
Weight gain	=	9 MJ
Pregnancy	=	8 MJ

The cows daily energy needs are **169 MJ** per day

Different options can be quickly and easily explored using these calculations:

Example. Feeding rolled barley to cows in late lactation:

You've been offering the cow in the example box 100 m^2 per head per day of pasture as the only feed, and there's 1300 kgDM available pasture per ha (grazing from 2600 kgDM/ha down to 1300 kgDM/ha). This equals 13 kgDM/cow/day eaten as pasture. You notice that MS production is at 1.4 kgMS per cow per day, but that cows are losing a little weight and that they're are starting to chew lower than the 1300kgDM residuals you've been targeting.

You calculate that the daily MJME demand for 1.4 kgMS is for 169 MJME / cow / day (see the box), but that the 13 kgDM per head per day from pasture is only delivering around 149.5 MJME if the pasture is 11.5 MJME/kgDM.

You decide to start feeding rolled barley in the shed and offer 2.0 kg as fed per head per day. This works out to 1.76 kgDM (barley at 88% DM x 2.0 kg) and 22 MJME (1.76 kgDM x 12.5 MJME / kgDM).

After 2 weeks of feeding barley, you're disappointed to see the cows have only responded by producing an extra 0.12 kgMS / cow / day.

WHERE HAVE THOSE potential MS from the barley GONE??

If ALL this extra energy from the 2.0 kg of barley went to MS, this should give us 22/65MJME/kgMS = **0.338 kgMS / cow / day**. BUT hang on, they've only produced 0.12kgMS / cow / day, leaving a "missing" 0.218 kgMS. Barley feeding can't be economic at that price, right? WRONG!

The extra nutrients from the barley simply do not disappear into thin air. Follow the check list of:

(a) *Is the barley being well processed (no or very little whole grain in the dung).*

Loss of considerable amounts of whole grain can reduce apparent conversion efficiency of barley grain to MS.

(b) *Are the barley weights correct in the bail?*

Collect the allocated amount of grain into a container and weigh the amount (from several points in the shed if a herringbone in shed feeding system).

(c) *Are the cows gaining weight?*

E.g. you may have noticed that during the two weeks of feeding barley, the cows have gone from a **4.0 BCS to 4.2 BCS**. If we value one BCS as 30 kg of liveweight for a larger black and white cow, this means around 6 kg of liveweight gained. For THIS example, the cows only produced 0.12 kgMS from 2.0 kg of barley. It takes around 7.8 MJME to produce 0.12 kgMS (0.12 x 65 MJME/kgMS).

The barley was giving the cows 22 MJME/day for only 0.12 kgMS return, meaning there was around 14.2 MJME per day that has gone elsewhere. If we divide the requirement for 1 kg of liveweight gain (35 MJME/kg liveweight) by 14.2 = 0.406 kg weight gain per day over the last 2 weeks = 5.7 kg of liveweight gain over two weeks.

OUR ANSWER – the 'missing' kgMS has actually gone to liveweight gain, with cows gaining 0.2 of one BCS (just under 6 kg of liveweight) in two weeks. Remember that this is not a bad outcome, particularly if this means that lighter conditioned cows can remain in milk for an extra few weeks and you can fine tune your winter feed budget to feed less to the dry cows as they'll be drying off in heavier body condition score.

By better understanding the characteristics of different supplements offered on farm and by accounting for some key limitations and constraints with each type, annual planning sessions can focus on feeds that are most likely to support the best MS response. Accurately predicting MS responses to a given tonnage of feed can be problematic due to multiple interacting factors including cow condition, environmental conditions, and factors that impact on silage harvesting and ensiling. For any supplement in your system, identify weaknesses associated with that feed and aim to modify what you can to enhance utilisation of the feed and it's conversion to MS and body condition. In many cases, planning needs to start well before feed out of supplements and for silage, well before the silage is harvested. Start your planning today!