FARM

beef+lamb new zealand

FACT SHEET

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UNDERSTANDING FEED QUALITY

This factsheet provides a practical understanding of:

- the role of forage quality in estimating animal intake and performance
- how to identify and fill feed gaps
- tools to calculate these gaps

Key take home points

- Test for feed quality; it cannot be seen
- Compare feed quality parameters (neutral detergent fibre (NDF), protein and energy) with animal requirements
- Is the feed protein deficient or energy deficient? Or is NDF limiting the intake?
- Decide on appropriate choice of supplement
- Calculate amount and cost-effectiveness of supplement required

There are inherent differences in feed quality between plant species and their components (such as leaves, stems and roots or tubers). In turn, the nutritive value of these components differs according to stage of maturity and the conditions under which they are grown. Daily dry matter intake (DMI) is also affected by the components of the pasture sward that are selected by the grazing animal, its water content and the time spent grazing. The rate at which forage is digested is a key determinant of dry matter intake and largely influenced by the fibre concentration of the feed on offer.

Why feed quality is important

Feed intake is influenced by the amount of feed on offer only when dry matter availability, supply and palatability are limited. Feed quality is the primary driver of feed intake and animal productivity.

The quality of the feed on offer also determines the type and amount of supplements required.

Feed quality factors of major importance include:

- Crude protein
- Metabolisable energy
- Neutral detergent fibre
- Minerals and trace elements

How to determine feed quality

Green pasture is of higher quality than dry pasture is. However, beyond that point, visual estimation of feed quality can be unreliable and inaccurate, particularly when animal performance is important (such as during: pre mating, pre lambing and pre weaning).

Testing pasture, hay and grain is a cost-effective and simple exercise, which allows comparison between animal requirements and the quality of feed on offer.

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Key nutrients explained

Testing laboratories measure (or estimate) and report feed quality on a per kgDM basis, because the nutrients a ruminant needs from its diet are contained in the dry matter (DM) portion of the feed. The higher the water concentration of a pasture or silage, the more the animal must consume to reach its daily dry matter intake.

For example, a 65kg, twin-bearing ewe in late pregnancy:

Green winter pasture 12% DM; silage 50% DM
- Daily requirement = 1.74kgDM per day
- Therefore, she needs to eat:
  - 14.5kg of wet pasture
  - 3.48kg wet silage (a ewe will not be able to eat this much silage)

1. Crude protein

Crude protein (CP) = a measure of the nitrogen content of a feed, including true protein (amino acids) and non-protein nitrogen (e.g. urea).

From a practical perspective, protein drives performance – such as growth, reproduction, muscle development, milk and wool production – and is a key nutrient required by rumen bacteria. Prolonged grazing of low protein dry pasture or feeding low protein hay can decrease the rumen bacterial populations required for efficient digestion.

Crude protein is expressed as a percentage of dry matter (DM) and should be converted to grams per kg of DM (CP% x 10) to calculate daily requirements. E.g. CP= 15%= 150grams CP/kgDM

Testing laboratories measure the nitrogen content of a forage and calculate crude protein using the formula CP = N% x 6.25.

N.B. Where conserved forage has been baled too wet, the crude protein measurement does not account for heat damage, which may reduce protein availability.

2. Metabolisable energy

Metabolisable energy (ME) = the amount of energy produced from the digestion of feed and available for productive purposes after accounting for that lost in urine, faeces, belching and maintenance requirements.

Metabolisable energy is expressed in the units ME per kg of DM or total megajoules per day. In most testing laboratories ME is calculated from digestibility and is therefore often reported as "estimated" ME.

3. Neutral detergent fibre

Neutral detergent fibre (NDF) =
a measure of the forages' total cell wall or fibrous fraction, which consists of celluloses and lignin.

As forage NDF increases, the amount of feed an animal is able to eat decreases. NDF is expressed as a percentage of dry matter and, as for crude protein, needs to be converted to grams per kgDM (NDF% x 10) to calculate daily requirements.

NDF can be used to estimate potential intake of DM by the following equation:

Dry matter intake (DMI) = liveweight x (120/NDF)

For example, compare the potential DM intake of a 65kg ewe eating a high vs. lower quality forage:
- NDF 68% (dry, rank pasture)
  - DMI = 65 x (120/68)%
  - DMI = 65 x 1.76%
  - DMI = 1.14kgDM per head per day
- NDF 48% (good quality pasture, silage and high quality legume hay)
  - DMI = 65 x (120/48)%
  - DMI = 65 x 2.5%
  - DMI = 1.63kgDM per head per day
- NDF 28% (high quality forage brassica)
  - DMI = 65 x (120/28)%
  - DMI = 65 x 4.28%
  - DMI = 3.12kgDM per head per day

As a general rule, the lower the fibre concentration (NDF) of the diet, the more an animal will potentially be able to eat in one day. That said, animals cannot be relied upon to limit their intake to their daily requirements. This impacts on stocking rate decisions and the number of days a paddock can be grazed.

"Digestibility" is a feed characteristic often referred to in nutritional articles, however it is a measure with little practical application in the field. The correlation between NDF and digestibility is high (-0.81) – thus the higher the NDF, the lower the digestibility.

4. Minerals and trace elements

Mineral deficiencies are often the first place farmers look when stock productivity is lower than expected. However, in the vast majority of cases, it is an imbalance of demand vs. supply of dry matter, protein and/or energy in the diet that is the problem. That is not to discount the importance of mineral deficiencies where and when they do occur. The most important macro mineral in a ruminant diet is calcium and, in the case of cattle, magnesium deficiency can cause grass tetany in spring.

Critical trace elements likely to be deficient in New Zealand include copper, cobalt, iodine and selenium (Grace, 1983)[1]. However, these deficiencies tend to be farm-specific. (See final section for more details.)

Pasture testing is strongly recommended to determine the extent of the deficiencies and/or any interactions likely to be impeding nutrient availability. Test when pasture is green and again when it has dried off, as deficiencies not found in spring may be significant over summer.

When feed quality is important

The higher the quality of the feed, the less an animal needs to eat to meet daily protein and energy requirements. It therefore follows that the smaller the animal (or, more importantly, the smaller the rumen), the greater the importance of high quality forage availability.

Dry matter intake is largely a factor of body weight. Furthermore, pasture quality declines with increasing pasture maturity. Therefore, larger animals (such as cattle) do better on lower quality feed than weaner lambs. To optimise growth rates in weaners, the smallest animals should be provided with the highest quality forage available.

The last trimester of pregnancy presents many challenges for forage-based twin- or triplet-bearing ewes. The smaller the ewe (60kg vs. 80kg), the less she is able to eat to meet her daily requirements, so pasture quality is particularly important. As foetal growth rapidly increases in late pregnancy, there is some degree of ruminal compression due to the space taken by the uterus. This limits the ewe's capacity to increase intake to meet an increasing nutrient demand.

Table 1: Daily nutrient requirement of a 30kg and 40kg lamb growing at 300g/day and a 65kg twin-bearing ewe in mid-pregnancy (Adapted from NRC, 2007)[2]

	DMI Potential	DMI	ME	ME density required	Crude protein	CP	NDF (max.)	Ca	P
	% of LW	*kg/day*	*MJ ME/ day*	*MJ ME/kg DM*	*grams/ day*	*% of DM*	*% of DM*	*grams/ day*	*grams/ day*
Weaned lamb - 30kg; LWG300g/d	4.15%	1.25	14.94	11.95	155	12.4%	29%	8	4
Weaned lamb - 40kg; LWG300g/d	3.22%	1.29	15.44	11.97	160	12.4%	37%	8.2	4.1
Mid- preg: twin-bearing - 65kg	2.56%	1.67	15.10	9.04	160	9.58%	46%	7.3	4.8

Table 1 shows the challenges weaned lambs face in reaching their genetic potential for growth, and the importance of sampling and testing pasture. Only the highest quality pastures exceed 11.97MJ ME. Alternatively, the animals need to be allowed to select only the highest quality components from a paddock before being shifted. Although a green pasture is higher in quality than a dry one, the differences in protein, ME and fibre (NDF) between two green pastures can result in significant differences in animal performance (Table 2).

Table 2: Pasture test results (June 2016) – North Island. (Adapted from feed analyses collected by R. McNutt)[3]

Paddock	Sample Type	NDF %DM	Potential intake % of Body Weight	MAXIMUM Dry Matter Intake kg/Day	Crude protein %	ME MJ/ kgDM	MAXIMUM Energy Intake kg/ Day	Stock Class	Live-weight kg	Maximum Liveweight Gain/Day
1	Kale	19.0	6.3%	2.53	14.7	13.5	34.11	Lamb	40	>300gm
2	Plaintain/ white clover	23.2	5.2%	2.07	27.0	12.6	26.07	Lamb	40	>300gm
3	Plaintain/ white clover	24.5	4.9%	1.96	23.1	11.7	22.92	Lamb	40	>300gm
4	Plaintain/ white clover	19.0	6.3%	2.59	14.7	13.5	34.96	Lamb	41	>300gm
5	Ryegrass/ native pasture	40.4	3.0%	1.19	31.7	12.3	14.61	Lamb	40	175gm
6	Ryegrass/ native pasture	43.1	2.8%	1.11	30.4	12.1	13.48	Lamb	40	150gm
7	Ryegrass/ native pasture	44.5	2.7%	1.08	23.7	11.1	11.97	Lamb	40	100gm
8	Grass Baleage	49.0	2.4%	1.47	10.8	9.6	14.11	Ewe	60	75gm
9	Ryegrass/ native pasture	51.3	2.3%	0.94	15.5	8.9	8.33	Lamb	40	Maintaining weight
10	Lucerne Baleage	51.5	2.3%	1.40	14.2	8.3	11.60	Ewe	60	25gm
11	Ryegrass/ native pasture	57.8	2.1%	0.83	17.5	7.9	6.56	Lamb	40	Losing weight
12	Ryegrass/ native pasture	58.3	2.1%	0.82	16.0	7.7	6.34	Lamb	40	Losing weight

How to identify and calculate feed gaps on your farm

First determine:

1. What class of animal and stage of production (i.e. dry ewe or growing lamb)?
2. How much does the animal weigh?
3. What does the animal need (i.e. daily requirements for protein and ME)?
4. What is the quality of the feed on offer?
5. How big is the feed gap (demand vs. supply)?
6. How to fill that gap? What with and will it be cost-effective?

Example 1: Weaned lamb @ 40kg LW

Daily requirements (see Table 1) to be able to grow at 300g/day:
- Dry matter intake (DMI) capacity = 1.29kg
- ME requirements = 15.44MJ or 11.97MJ ME per kgDM
- Protein requirements: 160grams per day or 12.4%
- Maximum NDF in forage = 37%

Assume the pasture tests in Table 2 represent paddocks on your farm where you have the option of grazing the weaned lambs. Which paddock would be the closest match to the lambs' requirements?

Answer: Paddock 4

Why Paddock 4?
- NDF is below the maximum limit of 37%, therefore there is no limit to daily intake.
- Protein concentration is higher than the required 12.4%.
- ME availability is deficient by only 0.27MJ, if the lamb does not exceed its required daily DM intake of 1.29kg/day. However, the NDF of this pasture is not limiting intake, so an increase in daily dry matter intake of 23 grams of pasture would ensure daily ME needs were met.

Example 2: Mature ewe, mid-pregnancy, slowly gaining weight @ 65kg

Daily requirements (see Table 1) to slowly gain weight in mid-pregnancy:
- Dry matter intake (DMI) capacity =1.67kg
- ME requirements = 15.10MJ or 9.04MJ ME per kgDM
- Protein requirements: 160grams per day or 9.58%
- Maximum NDF in forage = 46%

Assume the pasture tests in Table 2 represent paddocks on your farm where you have the option of grazing ewes in mid-pregnancy. Which paddock would be the closest match to the ewes' requirements?

Answer - Paddock 6

Why Paddock 6?
- It is the best of a "bad lot".
- NDF is below the maximum limit of 37%, therefore there is no limit to daily intake.
- ME is below requirements by a deficit of 1.62MJ/day (15.1MJ vs. 13.48MJ).
- Protein availability, while not limiting, is higher than is necessary or desirable.
- With a deficit of 1.62MJ ME, offering a low protein supplement such as maize (corn) or cereal grain at a rate of 120grams per head per day would overcome this. This is calculated by:

Required MJ = 15.1
Available MJ = 13.48
Deficit = 1.62

Cereal grain ME = 13.4MJ ME/kgDM
1.62/13.4 = 0.12kg or 120grams

Why not Paddock 7?
- Although the protein concentration of the pasture is lower, the ME deficit is greater (3.13MJ). This would increase the cost of supplementation (234 grams of grain per head per day) in this paddock.

Choosing the most complementary supplement

Feed supplements are best used to complement the available feed. For example:

- When protein is limiting production, a high protein hay, silage or grain will be the best complement and, as a general rule, will also be the most cost-effective.
- Where there is an energy deficiency identified, cereal grain is the ideal supplement. If the remainder of the diet is high in protein, it is best to choose a low protein feed.
- If paddock feed (i.e. forage) is deficient, such as during winter, then a forage-based supplement would be the feed of choice. However, over summers following a good spring, there may be an excess of dry pasture to be grazed. Grain supplementation will enhance feed utilisation and increase the nutritive value of the total ration (Table 3).

The choice of supplement depends on the:

a) amount and quality of paddock feed available AND
b) status of the grazing animals and their changes in nutrient demand throughout the year.

For example, when lambs are weaned:

If a percentage of the ewes are in sub-optimal body condition (below BCS 3), use a lot of feed to get there. This approach is preferable to gradually increasing body condition over the next 100 days to joining. Why? Because short-term supplementation with a high-energy cereal grain will preserve some paddock feed and return the ewes to ideal body weight more quickly. This also allows them to maintain condition over summer, with lower nutrient requirements, which may better match the quality of feed on offer.

Table 3: Typical characteristics of a pasture-based system and choice of supplement to complement the nutritive value of the feed on offer

Season	Paddock feed	NDF	Protein	Energy	Supplement (only if required)	Ewe status	Lamb status
Autumn - dry	Minimal; dry +/- small green pick	High	Low	Low	High quality forage	Joining	Weaners
Autumn - wet	Adequate; green	Mod	Mod	Mod	Grain	Joining	Weaners
Winter	Minimal; green, low DM	Low	High	Low	High quality forage	Pregnant	
Spring	Plentiful - highest nutritive value	Mod	Mod	Mod	Nil	Lactation	
Summer	Plentiful - falling → low NV	High	Falling	Falling	Grain	Dry	Weaners

Choice of supplement

The smaller and lighter the animal, the higher the feed's nutritive value needs to be, due to limited rumen capacity. Therefore, high quality hay is a better supplement of protein and energy than very wet silage (<50% DM), and high protein, high ME grain should be used when paddock feed is not limiting. Wet silage and low quality hay are better fed to larger animals, such as crossbred ewes or cattle.

The choice of grains often comes down to cost and availability. However, the choice should be made on its cost per MJ ME and/or cost per gram of protein, and based on replacing the missing nutrients in the animal's diet.

Another consideration in grain selection may be the risk of acidosis and the time available to slowly introduce the grain to allow adaptation of the rumen bacteria in acidosis prevention. Oats and lupins are the safest grains to feed, because the introduction time is minimal. Conversely, wheat requires introduction over 14 days.

If pellets are an option, the same considerations apply. Unless they are a hay-based pellet (in which case, they may be a suitable substitute for both hay and grain), they should be treated the same as wheat and their use based on their nutritive value and cost-effectiveness.

Helpful link: Feed cost calculator (NSW Department of Primary Industries) www.dpi.nsw.gov.au/animals-and-livestock/nutrition/costs-and-nutritive-value/feed-cost-calculator

This online tool calculates and compares protein, energy and other components for different mixes of livestock feeds.

Supplementation of minerals and trace elements

The most important mineral for growing lambs and pregnant ewes is calcium. Lambs require a ratio of calcium to phosphorus of 2:1 to optimise bone growth and reduce the risk of urinary calculi formation in wether lambs when grazing low calcium (grass-dominant or cereal-based) pastures.

Addition of trace elements to supplementary feed is often the most expensive way to correct deficiencies.

- **Where copper, cobalt and selenium deficiencies exist**, intraruminal pellets are the most cost-effective form of supplementation.
- **Selenium deficiency** alone can be corrected with a long-acting injection every 18 months for sheep and annually for cattle. Selenium can also be applied as prills with fertiliser, orally drenched or given intraruminally as a bolus or pellets.
- **Seasonal deficiencies of cobalt** can be effectively treated with a short-acting injection of Vitamin B_{12}, particularly for animals destined for early slaughter, such as weaned lambs.
- **Copper deficiency** is complicated by the fact that the treatment and prevention of either primary or secondary deficiency are quite different. Secondary deficiency (often induced by inherently high soil concentrations of molybdenum effectively "locking up" copper) is more difficult to overcome. Paddock application of copper sulphate is often a more cost-effective method of prevention, however effective management should involve consultation with both veterinary and agronomic advisors.
- **Iodine deficiency** is more commonly seen when brassica species are being grazed, in particular kale, but seasonal and annual variations occur (Grace, 1983)[1]. The most effective forms of supplementation include potassium iodide drench or iodised oil injections.

Conclusion

Feed quality cannot be assessed by eye. Testing and therefore quantifying the protein, energy and NDF components allows you to make informed decisions about the type of supplement to use and its cost effectiveness.

B+LNZ RESOURCES

www.knowledgehub.co.nz

- **Resource book** - Pasture Quality Q graze
- **Learning module** – Feed Fundamentals

External resource

- **PDF -** Use of Trace Elements in New Zealand Pastoral Farming www.fertiliser.org.nz/includes/download.aspx?ID=123583

References

[1]Grace, 1983- Managing Mineral Deficiencies in Grazing Livestock

[2]NRC, 2007- National Research Council (2007) Nutrient Requirements of Small Ruminants – Sheep, Goats, Cervids and New World Camelids.

[3]R. McNutt- Pasture test results from the Hawkes Bay district NZ collected and collated by Rebecca McNutt (2016, unpublished)