5. Nutritional value

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Leucaena-grass systems can achieve about double the live weight gains that might be achieved on native pastures alone. Steers can gain 0.6–0.7 kg/hd per day over an entire year, approaching 1.2 kg/hd/day over 80–120 days under favourable conditions.

On well managed leucaena-native grass pastures on good basalt soil, steers have gained as much as 0.84 kg/hd/day over 167 days in the dry season and 1.16 kg/hd/day over 119 days in the wet season.

On a dry matter basis, leucaena browse (leaf with minimal stem) can have more than five times the crude protein content (CP) of tropical grass pasture in the dry season, with nearly twice the (metabolisable energy (ME) and half the fibre (ADF and NDF fractions). When eaten with grass, leucaena improves the balance of nutrients consumed, increases overall feed intake and greatly improves feed conversion efficiency – resulting in more LWG per kg DM consumed.

Leucaena dry matter (DM) has:

- crude protein concentration of 20–25% (leaf with minimal stem)
- digestible organic matter (DOM) of more than 60%
- metabolisable energy value above 10 MJ/kg DM
- rumen degradable protein to digestible organic matter ratio of 188–236g RDP/kg DOM – well above the rumen microbial requirement of 130g RDP/kg DOM.

The crude protein content and digestibility of a leucaena-grass diet will vary depending on the proportion of leucaena in the diet. With paddock grazing, and in some cut-and-carry systems, animals select leaf and reject woody stems with a diameter greater than 6–10mm. However where leucaena is mechanically harvested through a forage chopper, animals have difficulty selecting leaf and the overall diet CP% and DMD of the diet will be reduced.

5.1 Leucaena as a total supplement

Crude protein supply

The high CP content of leucaena is its major nutritional advantage over other tropical forages. The addition of leucaena to pasture-based systems can remove the need for protein supplements such as urea and cottonseed meal in the dry season.

For rapid growth (more than 1kg LWG/day), cattle need about 13% crude protein in their diets and they cannot get this from grass alone (Figure 5.1).

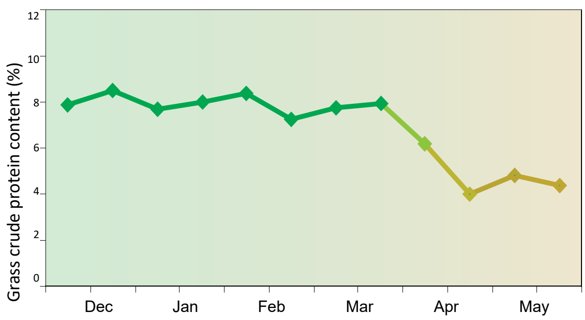
Adequate leucaena mixed with a tropical grass increases metabolisable protein (MP) to the animal providing the building blocks for milk and muscle production.

Acronyms

Some readers may be accustomed to the acronyms used in nutrition science, others less so. These are spelt out here for readability.

ME – metabolisable energy
MJ – megajoule
DM – dry matter
DOM – digestible organic matter
CP – crude protein
RDP – rumen degradable protein
MP – metabolisable protein
NDF – neutral detergent fibre
CT – condensed tannins
VFA – volatile fatty acids
DHP – di hydroxy-pyridone
LWG – live weight gain

Figure 5.1: Change in grass protein (December to May)



Crude protein is either degraded in the rumen (RDP) by the rumen microbes (beneficial bacteria, fungi and protozoa), or escapes (flows out of the rumen before being degraded) or, being indigestible by the microbes, bypasses to the small intestine. The CP degraded in the rumen is used by the microbes to grow and multiply and is the major source of MP for the animal when it moves out of the rumen and is digested further down the tract. The escape and bypass protein components make up a much smaller part of the total MP.

The higher RDP fraction of leucaena improves feed intake of low quality tropical grass in the dry season. This can enable cattle to at least maintain live weight during the dry season when cattle on grass-only pastures would be losing weight.

Energy supply

Higher dietary ME is also achieved by feeding leucaena. Higher DOM provides the energy that directly feeds the rumen microbes.

The microbes consume the DOM fraction and excrete volatile fatty acids (VFA) which are absorbed across the rumen wall into the animal's blood stream where they are transported to the liver to be converted to glucose (the animal's actual energy currency).

Glucose is the energy source that fuels maintenance and productivity or the production of muscle and fat. More glucose and MP stimulate more LWG, driven by more leucaena relative to pasture in the diet.

Volatile fatty acids

Not all volatile fatty acids are equal in terms of their glucose-producing potential in the liver. The growth of muscle and fat is especially efficient if the microbes produce a greater proportion of propionate to acetate (two different types of VFA), and this occurs in pasture-fed cattle supplemented with leucaena.

Condensed tannins, protein and bloat

Leucaena contains condensed tannins (CT), secondary compounds which bind to protein, at concentrations of 3–6% DM. While leucaena CT do not generate much usable bypass protein, the CT in leucaena do protect cattle from bloat.

Forages that contain high CP (such as immature lucerne) would normally be considered a bloat risk. Excess protein in lucerne degrades rapidly in the rumen to produce a stable foam that causes bloat. In leucaena, CT bind to enough of the leucaena protein in the rumen to slow down the rate of degradation, negating the foaming risk.

Minerals supply

Leucaena-grass pastures would be expected to have sufficient mineral content to support high cattle performance when established on suitable country and not on marginal soils. Leucaena on its own is a rich source of calcium and magnesium needed for strong bones and healthier metabolism. However, if cattle consume high amounts of leucaena, sodium and zinc could become limiting. Any deficiency from this or from marginal soil can be managed by providing a mineral lick.

5.2 How much leucaena in diet?

The optimal proportion of leucaena in the diet will depend on the targeted level of LWG and the nutritional value of the grass or other supplements in the diet.

Very high intakes of leucaena potentially waste protein if it is not balanced with enough grass or other energy supplements.

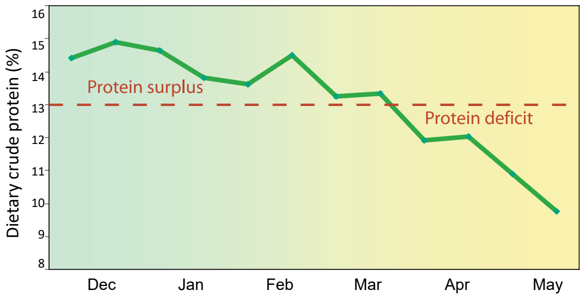
Overall, a nutritional aim across the season or whole year should balance the higher CP and ME in leucaena with the lower levels in grass to bring the overall level of the diet closer to the nutritional requirements of the animal (CP of 13–15% and ME of 8–10 MJ/kg DM). Cattle can obtain fibre from high leucaena diets by stripping the bark from stems.

However, the grazing behaviour of cattle on leucaena commonly makes it difficult to achieve that desired balance of leucaena to grass.

Cattle can maintain weights on dry season grass with small amounts of leucaena (5-10%) in diet. At these levels, leucaena effectively acts like a urea-enriched supplement; increasing total dietary CP% at a time when dry season grass could be 6% CP or lower.

Overall, cattle often prefer young nutritious grass early in the season and leucaena later in the season as the grass matures. However, if the leucaena area and associated grass is limited, cattle will keep eating the more palatable leucaena while it is available. Without a careful grazing strategy, cattle will tend to consume excessive amounts of leucaena protein early in the growing season — more than they need nutritionally — leaving insufficient leucaena forage for when the grass hays off in autumn (Figure 5.2).

Figure 5.2: Cattle grazing abundant leucaena in summer may be wasting protein needed in autumn

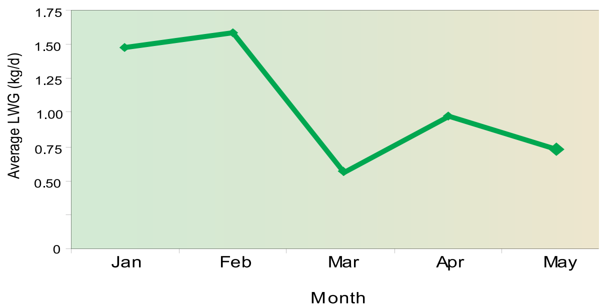


Cell or rotational grazing systems can be used to manage leucaena intake.

For higher LWG

Weight gain sufficient to finish steers (1–1.4 kg/AE/day) for high value markets is attainable in the wet season but not year round. As the dry season progresses, LWG will decline depending on how much leucaena is available at the time (Figure 5.3).

Figure 5.3: Cattle grazing abundant leucaena in summer may have insufficient in autumn



When cattle are introduced to leucaena paddocks in the wet season, they immediately select a high proportion of leucaena resulting in a high intake of crude protein. For cattle accustomed to leucaena, leucaena intake can initially exceed three quarters of the diet and then gradually reduce as leaf becomes less available, to less than one quarter of the diet by the beginning of the dry season.

To achieve high LWG into the dry season, the leucaena proportion in the diet must be maintained or animals would need to be supplemented with high quality silage or hay, winter active pastures such as oats, and/or energy-rich supplements such as molasses or grain (See Producer experiences – Craig Antonio, Don Heatley).

These strategies would also apply to cows and first calf heifers in early lactation.

The economics of these strategies require careful consideration, they are more complex to manage, and potentially increase the risk of digestive problems such as ruminal acidosis.

LWG for other classes of stock

It may be suitable to target moderate levels of productivity for some other classes of cattle than steers alone. Lower (less than 33%) rather than higher (more than 33%) levels of leucaena relative to grass in the diet would suit cattle with relatively low requirement targets such as heifers to calve at three rather than two years of age, pregnant rather than lactating cows (but not during the first trimester due to the risk of foetal abortion), or bullocks to be finished in more than three years rather than steers to be finished or sold into feedlots before 2.5 years of age.

5.3 Leucaena toxicity

While leucaena-grass pastures are the most productive, sustainable and profitable improved pasture option for northern Australia, concern about leucaena toxicity and its management has limited its adoption and potential as a forage for ruminants.

The toxicity of leucaena results from the presence of a non-protein free amino acid, mimosine, which occurs in high concentrations (4–12% DM) in foliage and pods and can have severe short-term effects on animal health and performance.

Leucaena toxicity explained

Mimosine is rarely severely toxic as it is normally broken down to DHP, but toxicity can occur when unaccustomed hungry cattle gorge on lush new leucaena growth at the break of a drought or directly after frost before companion grass pasture starts growing.

The acute mode of toxicity is initially due to the effects of mimosine on rapidly dividing cells – resulting in hair loss, salivation, loss of appetite, low bull fertility, foetal abortion in pregnant cows and, very occasionally, death.

Preventing acute mimosine poisoning

- Do not let hungry cattle gorge on lush leucaena.
- Make sure there is ample roughage (grass or hay) available in the paddock to minimise the risk of cattle eating too much leucaena too quickly.
- Introduce them to leucaena slowly to give time for mimosine to be converted to DHP.
- Give cattle time to adapt to high leucaena diets.
- Mimosine toxicity is remedied by immediately removing the animal from the leucaena.

To avoid the risk of fatal acute mimosine toxicity, do not allow cattle to gorge on leucaena regrowth after a frost or drought without adequate grass roughage.

However, after a short adaptation period of 1–2 weeks, mimosine is rapidly and effectively converted by enzymes and rumen bacteria to less acutely toxic compounds, isomers of dihydroxypyridone (known as DHP).

From mimosine to DHP

Acutely toxic mimosine is rapidly (within 1–2 weeks) converted by plant enzymes and rumen bacteria to less toxic compounds, isomers of dihydroxypyridone (known as DHP).

DHP itself is a goitrogen inhibiting thyroid hormone function and can be responsible for reducing feed intake and animal performance.

DHP strongly binds to essential metal ions leading to mineral deficiencies.

Cattle adapt to DHP with rumen microbes which degrade the toxin and by the action of the liver which neutralises and excretes toxins in urine.

Cattle can adapt to DHP toxicity through two mechanisms:

- Rumen microbes (the 'rumen bug') which can degrade DHP.
- DHP toxin absorbed into the bloodstream can be neutralised by binding compounds produced in the liver (a process called conjugation). The neutralised toxin is excreted in the urine.

See next page **Is there a different DHP detox pathway?** to understand the latest research in management of toxicity.

Administering the rumen inoculum

The 'leucaena bug' (*Synergistes jonesii*) can be purchased through the Queensland Government web site. The inoculum has been licensed by the Australian Pesticides and Veterinary Medicines Authority (APVMA) to be administered orally using a standard cattle drench gun.

The mixed culture bacterial inoculum is stored at –20˚C and distributed frozen on wet ice in 500mL bottles. It must be handled carefully to ensure the bacteria survive, and should be thawed only immediately before drenching and with minimal exposure to air.

As the live bacteria in the inoculum are adapted to oxygen-free environments (as in the rumen), they cannot be applied to a water source (such as a trough) because oxygen in the water will kill the bacteria.

The recommended dose rate is that 10% of animals in the herd be inoculated with 100mL of culture each using a standard drenching gun. This means the 500mL bottle will treat five animals in a mob of 50.

Administering the 'leucaena bug' with a drenching gun

Further information on the use and management of the leucaena inoculum can be obtained from *https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/livestock/cattle/leucaena-inoculum-cattle*.

Managing cattle to prevent leucaena toxicity

Leucaena toxicity occurs when unadapted cattle first access lush leucaena, especially at the break of the season and when little grass is available.

Naïve animals must be introduced to leucaena slowly; providing adequate grass or hay roughage will assist in preventing the animals gorging on leucaena. This will allow the rumen microbes and animal's liver function time to up-regulate to detoxify the DHP.

Once adapted, cattle can be safely grazed on leucaena pastures without experiencing toxicity. However, first-calf heifers must be protected from mimosine toxicity if they have not been previously adapted.

Naïve pregnant cows should not be introduced to leucaena, especially during the first trimester, due to the possibility of foetal abortion.

It is a good strategy to adapt breeders by initially exposing them to small amounts of leucaena. Once adapted, heifers can safely eat diets containing high proportions of leucaena, and stud and herd bulls can be safely fed on leucaena (see Producer experience 4.5).

Is there a different DHP detox pathway?

Since the early work by Dr. R.J. Jones and colleagues in CSIRO identified a rumen bacterium (*Synergistes jonesii*), further studies on leucaena toxicity by the University of Queensland and CSIRO have found *S. jonesii* to be less effective than originally thought.

There have always been queries about how *Synergistes* can spread quickly through a herd in which only one in ten animals initially received an inoculum, and many producers do not inoculate regularly.

Testing of urine samples collected from many cattle herds on high leucaena diets in Queensland has indicated that DHP was not all degraded by *Synergistes jonesii*; rather it showed the potential importance of a lesser known pathway in which DHP toxin is neutralised by conjugation in the liver.

Taking urine samples for DHP testing from cattle eating leucaena in Queensland

Strong evidence for an alternative pathway of toxin management was previously found in Indonesia where numerous Balinese farmers feed uninoculated Bali bulls (*Bos javanicus*) with up to 100% leucaena. The bulls show no toxicity symptoms – apart from some hair loss, salivation and reduced appetite over an initial 1–2 weeks while they became adapted to the new diet. The bulls quickly recover and are not only healthy but gain weight at near their genetic maximum.

Urine tests showed that the Indonesian cattle were not degrading much of the DHP in the rumen, despite the presence of indigenous strains of *Synergistes jonesii*, but were excreting it in high concentrations in urine in the conjugated non-toxic form.

Ruminants in many tropical countries are commonly fed high leucaena diets – with no apparent long-term toxicity symptoms.

Bali bulls eating 100% leucaena and gaining weight without rumen inoculation.

Since there is no available source of *S. jonesii* in these countries, none of these ruminants are inoculated.

Urine sampling from cattle, buffalo and goats eating leucaena in Thailand and Mexico has shown the conjugation detoxification pathway.

All this evidence suggests that conjugation by compounds produced in the liver is a major pathway for neutralising the toxicity of DHP.

However until suitable research has been completed under Australian conditions, the recommendation remains for rumen inoculation with *Synergistes jonesii* as insurance against possible leucaena toxicity.

Other work has shown *S. jonesii* is not an isolated organism geographically. It can be found in the rumen fluid of animals in all countries tested, but always as a minor population just detectable using new PCR-based assays. Despite the ubiquitous nature of *S. jonesii*, its low resident populations in the rumen were insufficient to protect the animals from toxicity.

Further clarification needed on reproduction

Any toxic effects on the reproductive performance of ruminants consuming high leucaena diets need to be clarified.

Lowered calving percentages in females grazing leucaena have been reported by some Australian producers, probably due to foetal abortion, while other producers have reported that cattle accustomed to leucaena achieve high calving percentages. In Indonesia, where female cattle are adapted to high leucaena diets, there was no indication of foetal abortion.

Any negative effects on herd reproduction may be avoided by appropriate herd management.