AEGIC
Australian Export Grains Innovation Centre

Using lupins and barley in Asian dairy diets

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Key messages

- Australian lupins and barley are proven, reliable, high quality dairy feeds
- Lupins are really 2-feeds-in-1, as they are high in both protein and energy
- Barley is a great complementary grain to corn
- Consider these opportunities:
  - Use lupins to increase the energy and protein inputs of cows and young stock fed diets based on low quality forages
  - Use lupins as an alternative protein source, replacing some / all soybean meal / other oilseed meal / peas / beans
  - Use lupins as a safe alternative (low starch) energy source, replacing some of starch-dense energy sources in diet such as corn, cassava/tapioca
  - Use barley to the primary starch source or as a complementary starch source with corn, cassava/tapioca etc.
  - Use barley to help improve cow fertility

Lupins through the centuries

Lupins, like peas, beans, lentils, chickpeas, peanuts, alfalfa and soybeans, are pulses (seeds of legumes). For centuries, lupins have been valued as human and animal foods and as useful in grain crop rotation cycles to control weeds and pests and improve soil fertility and crop yields by fixing nitrogen.

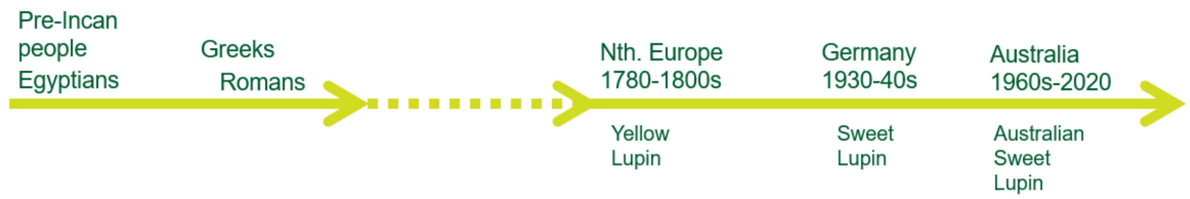

Figure 1. Lupin timeline – from ancient times to breeding of modern varieties

Today, lupins continue to be an important human food in developing countries where protein sources are limited. Lupins are also used in bakery products, pastas and noodles and as a meat additive and dairy food substitute in Australia, Asia and Europe. Lupins also have potential as a human nutraceutical due to their low glycaemic index, high levels of soluble fibre, unsaturated fat and arginine, and their absence of gluten.

Australian lupins

Australia produces approx. 730,000 tonnes of lupins per year (ABARE 5-year average to 2018-19). 80% of these lupins are grown in the Western Australian grain belt. Australia produces 80-85% of the world's lupins. About 30% of Australia's lupin crop is used domestically and 70% exported to Asia, North Africa and the Middle East for animal feeding.

About 40% of exported lupins are fed to dairy and beef cattle, 40% to pigs, and 20% to poultry, sheep and goats.

The main species of lupin grown in Australia are narrow-leafed lupin (*Lupinus angustifolius*) and, in smaller volumes, albus lupin (*Lupinus albus*). Australia has had a very active pulse breeding program since the 1960s, which has led to the development of many varieties of *Lupinus angustifolius* (commonly called Australian sweet lupin) and *Lupinus albus* (commonly called Australian white lupin) to suit different soil types and climatic conditions.

In contrast to the wild type of narrow-leafed lupin, the Australian sweet lupin has neutral tasting seeds, a non-shattering pod and a permeable seed coat, and is earlier flowering. Australian sweet lupin seeds weighs about 144 mg each. Twenty-five per cent of this is seed coat (hull) and 75% is kernel (cotyledons). Bulk density is about 0.78kg/dl (similar to that of wheat). Compared to the Australian sweet lupin, the Australian white lupin has a larger, softer seed and a thinner seed coat, and is slightly higher in protein and fat.

a) Nutritional value

Lupins are an exceptional ruminant feed ingredient. Lupins are really 2-feeds-in-1, as they are high in both protein and energy. Lupins' Metabolisable Energy value is higher than that of cereal grains and they are also a very good source of rumen degradable protein (RDP) for synthesis of microbial protein. In contrast to other legumes and cereal grains, lupins are low in starch and moderately high in NDF, so they don't depress fibre digestion or voluntary feed intake. Australian sweet lupin are about 6% oil and Australian white lupin about 10% oil. 75% of the oil comprises unsaturated fatty acids. Lupins are a good source of minerals, especially P, Mg and S and have a relatively low DCAD value.

10% of the nitrogen in lupins is non-protein nitrogen (NPN). Lupins are high in arginine but low in methionine compared to soybean meal and microbial protein. A feature of Australian varieties of *Lupinus angustifolius* and *Lupinus albus* is their very low levels of anti-nutritional factors. The alkaloid level is <0.2 g/kg DM vs >5,000 - 40,000 g/kg DM in bitter wild types of lupins grown in other countries. Levels of tannins, saponins and protease inhibitors are much lower than in soybean meal and peas. Levels of lectins, phytate and mycotoxins are also typically low. (Petterson, 2001). Anti-nutritional factors therefore do not limit the daily feeding rate of lupins to dairy cattle.

Table 1. Typical nutrient specifications of lupins and barley vs. other dairy feed ingredients

Feed	Crude protein (%DM)	Starch (%DM)	NDF (%DM)	Metab. Energy (MJ ME/kg DM)
Lupins	**34.5**	**3.1**	**25.9**	**13.8**
Barley	12.2	56.8	20	12.8
Wheat	12.9	66.9	13.1	13.3
Corn	9.3	72.5	10.7	13.5
Dried tapioca	3	73	11.8	12.3
Soybean meal	48	2.7	13.4	12.1
Peas	25	46.3	16.4	13.3
Beans	28.8	38.3	18	13.2

Source: Rumen8, 2020

b) Storage and processing

Lupins are easy to handle and store due to their low moisture level and robust seed coat which is impervious to insects. For feeding lupins to cattle, only coarse rolling to reduce particle size to 2-4.2 mm in required. (Lupins require more energy than grain to mill due to their harder seed coat). Heat treatment of lupins is not necessary. Sheep can be fed lupins whole as a pasture supplement

c) Production responses

Most research studies comparing dairy cows fed lupins vs. grains in the milking parlour have found that lupins produced more milk, fat and protein, while milk protein concentration tended to be reduced slightly. Other studies have found that substituting oilseed meals with lupins did not alter milk, fat and protein yields, although milk protein concentration was reduced slightly. Sheep studies have shown that feeding lupins to ewes stimulates ovulation rate. (White *et al.,* 2007).

When considering the use of lupins and barley grain in dairy cow diets, key principles of ruminant nutrition must be applied.

Dairy cows require nutrients, not specific ingredients

Dairy cows do not have requirements for specific ingredients. They are remarkably flexible animals, able to thrive on a wide variety of different types of forages and other feeds as used around the world. Rather, dairy cows have daily requirements for nutrients i.e. water, carbohydrates (sugars, starches, fibre), fats, protein, minerals and some vitamins. The objective is to meet cows' nutrient needs without excesses and within cows' intake limit with good feed efficiency and optimal diet cost and milk income minus feed cost.

Feeding dairy cows is all about balance

To maintain stable, healthy rumens, and therefore healthy, productive animals, digestion of protein in the rumen and post-ruminally in the small and large intestines must be balanced. The same applies to the digestion of starch. Designing well balanced dairy diets to achieve a target level of milk production involves using a feed formulation tool to repeatedly set and re-balance daily dry matter intake and levels of NDF, physically effective NDF, starch, sugars and protein levels to achieve the optimal diet cost and milk income minus feed cost. Mineral levels can then be readily optimised and any additives such as rumen buffers, probiotics and mycotoxin inhibitors included.

If the diet is unbalanced, rumen dysfunction may occur, leading to many problems such as reduced feed intake and feed efficiency, diarrhea, rumenitis, liver abscess, polioencephalomalacia and laminitis. The descent from healthy rumen function into ruminal acidosis due to excessive inputs of rapidly fermenting carbohydrates (i.e. starch and sugars) is a progressive one, from normal rumen function to sub-acute ruminal acidosis (SARA) to acute ruminal acidosis.

Opportunities to use lupins in Asian dairy diets

1. **Use lupins as a safe, easy-to-use feed ingredient to increase the energy and protein inputs of cows and young stock fed diets based on low quality forages**
   By using lupins in diets based on low quality forages, the following can be achieved:
   - Increased metabolisable energy density of diet
   - Increased dietary protein supply
   - Synthesis of more microbial protein in the rumen
   - Increased daily milk yield / growth
   - Increased cows' daily milk income minus feed cost through dilution of maintenance feed costs

2. **Use lupins as an alternative protein source, replacing some / all soybean meal / other oilseed meal / peas / beans**
   Some or all of the soybean meal / other protein sources in a diet may be replaced with lupins.
   If the diet is well balanced, dietary protein supply should be maintained while the diet's metabolisable energy density is increased, thereby sustaining current milk production. The cost:benefit of this will depend on the relative costs of the currently used protein source and lupins.

3. **Use lupins as a safe alternative (low starch) source of energy, replacing some of starch-dense energy sources in diet such as corn, cassava/tapioca**
   In circumstances in which cows are at moderate to high risk of ruminal acidosis due to herd factors, feed factors or feeding management factors, replacing some of the starch-dense energy sources in a diet such as corn, cassava/tapioca with lupins (which are low in starch but still high in energy) may be beneficial. This may also enable inputs of costly protein sources in the diet to be reduced.

Tables 2 and 3 show how a blend of lupins and either corn or barley alters the nutritional specifications, reducing the starch level and increasing the protein level vs. straight corn or barley.

Table 2. Typical nutrient specifications of corn, a 65:35 corn & lupins blend and lupins

Nutrient	Corn grain	Corn & lupins (65:35 blend)	Lupins
Dry matter (%)	88	88	89
Metab. energy (MJ/kg DM)	13.5	13.6	13.8
Crude protein (%DM)	9.3	18.2	34.5
Starch (%DM)	72.5	48	3.1
Sugar (%DM)	2	4	7.7
Fat (%DM)	4.2	5.2	7.1
Neutral detergent fibre (%DM)	10.7	16.1	25.9
Ash (%DM)	1.6	2.2	3.4
DCAD (mEg/kg DM)	-18	18	83

Table 3. Typical nutrient specifications of barley, a 70:30 barley & lupins blend and lupins

Nutrient	Barley grain	Barley & lupins (70:30 blend)	Lupins
Dry matter (%)	88	88	89
Metab. energy (MJ/kg DM)	12.8	13.1	13.8
Crude protein (%DM)	12.2	19	34.5
Starch (%DM)	56.8	40.5	3.1
Sugar (%DM)	3.4	4.7	7.7
Fat (%DM)	2.1	3.6	7.1
Neutral detergent fibre (%DM)	20	21.8	25.9
Ash (%DM)	2.5	2.8	3.4
DCAD (mEg/kg DM)	10	32	83

Opportunities to use barley in Asian dairy diets

1. Use barley as the primary starch source or as a complementary starch source with corn, cassava/tapioca etc.

If fermentable ME supply to the cow is limiting, this may lead to less microbial protein produced in the rumen and more ammonia absorbed across the rumen wall and converted to urea in liver. Most urea is excreted in the urine and some is recycled into rumen as NPN in saliva, requiring energy.

In these circumstances, inclusion of a more fermentable ME source such as barley in the diet may be useful to assimilate more rumen degradable protein (RDP) as microbial protein. This may reduce reliance on costly protein sources. Fermentable ME sources such as barley may also be useful if the diet contains high levels of rapidly degradable protein and non-protein nitrogen (NPN).

2. Use barley to help improve cow fertility

Barley is widely used in early lactation dairy diets as an energy-dense concentrate to 1) help reduce cows' body condition loss in early lactation, and 2) achieve higher body condition scores at mating. Research studies have shown that these two things are very important for improved cow fertility.

There is also interest in using barley as a source of rumen fermentable starch to increase cows' plasma insulin levels after calving, as research has been shown that this can increase follicular development in the ovary, leading to increased ovulation rate. (Gong *et al.*, 2002, Garnsworthy *et al.*, 2009, Burke *et al.*, 2010). However, further research is required to fully understand how manipulating dietary starch levels after calving can improve fertility under differing circumstances.

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