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Lupini bean – a bitter contamination risk for sweet albus lupins

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rapid adoption will assist the albus industry to eliminate the bitter contamination problem.

Plant biosecurity advice

Proclamation P129 under the *Plant Diseases Act 1924* regulates the importation or bringing into NSW of lupin plant material, used agricultural equipment and used packaging, as these could introduce the disease lupin anthracnose. The items may only be brought into NSW after written approval has been given by the Director, Animal and Plant Biosecurity, Industry & Investment NSW.

Any enquiries concerning the importation of these items should be directed to the Regulatory Compliance Manager on 02 6391 3384.

Alkaloid levels in albus lupins

Wild forms of the broadleaf lupin *Lupinus albus* contain high levels of bitter-tasting alkaloids in both the vegetative material and the seeds. **These alkaloids are highly toxic** and offer the plants some protection against insect attack and fungal diseases, as well as stress tolerance. Albus seeds with high alkaloid content are said to be 'bitter' to distinguish them from 'sweet' low-alkaloid types.

Bitter albus seeds are used as human food after they have been carefully soaked in water overnight. The majority of the alkaloids leach into the water, which is discarded. This method of preparation has been practised since antiquity. The residual alkaloids left after soaking give the seeds a 'tangy' taste that is preferred by consumers.

In the last 80 years lupins have been subjected to scientific breeding. One result of this effort was the discovery of genes that significantly reduce the alkaloid content of the plants and seeds. These genetically 'sweet' varieties can be eaten without soaking and without the risk of poisoning. They are also suitable for stock feed without prior treatment. Several different genes are known in albus for low alkaloid, but only one, called **pauper**, is used in the sweet lupin varieties grown in Australia. It is very important to maintain this uniformity, since bitter types will be produced by outcrossing between two sweet varieties containing different sweetness genes.

A small section of the albus human consumption market prefers large, bitter seeds. These are the so-called **lupini bean** types. Their use in this market sector is traditional in countries such as Italy and in migrant communities. Consequently, small quantities of lupini bean have been grown in Australia. These areas have tended to be isolated from the main sweet albus industry. The lupini bean areas tend to

Summary

- Most of the albus lupins grown in Australia contain low levels of seed alkaloids and are said to be 'sweet tasting'. High-alkaloid types are said to be 'bitter tasting'.
- Large-seeded, bitter albus lupin (also known as 'lupini bean') and bitter forage albus have the potential to contaminate sweet crops via pollen transfer (outcrossing) and admixture.
- Bitter contamination of sweet albus is irreversible, and contaminated seed must be replaced for sowing.
- Bitter contamination of sweet crops may compromise markets and may lead to rejection of deliveries.
- Growers are strongly advised not to plant bitter albus in the main growing areas for sweet albus.
- The new 'sweet' varieties Luxor and Rosetta have high yield and disease resistance. Their

be higher-rainfall, cooler-climate sites, such as the extreme lower south-east of South Australia, north-east Victoria (around Benalla and Myrtleford), and Tasmania, where large seed size and high yields are readily achievable. Small areas of lupini bean have also been grown in NSW in recent years.

Bitter albus varieties have been used as forage crops in some countries. The author is not aware of any bitter albus being grown in Australia for this purpose. However, if it were grown, the concerns detailed here surrounding lupini bean would also apply.

The mechanism for bitter contamination

Albus lupin is a **partially outcrossing species**. The rate of outcrossing can vary, but probably occurs at around 10%. Foraging honey bees are the main pollen vector. If sweet and bitter albus varieties are grown near each other there is a serious risk that pollen will be transferred between the varieties, particularly at the margins of the crop. In the bitter variety this will cause no significant problem. However, in the sweet variety the introduction of the bitter gene poses a serious threat.

Once introduced into a sweet variety, outcrossing will cause the bitter gene frequency to increase with each generation (season). Furthermore, it is also known that the bitter plants are 'fitter' than the sweet ones in the same population. They tend to be larger, healthier, and produce more seeds, especially in stressful seasons. When contamination of sweet lupin crops with bitter seeds reaches a relatively low frequency, the overall alkaloid level of the bulk crop will be in danger of exceeding the Food Standard for lupin alkaloids of 200 mg/kg. At increased bitter seed frequency, the seed lot will be less palatable to stock. At high frequency, poisoning could occur.

There is also a danger to sweet crops through admixture in farm equipment, transport vehicles, silos, seed cleaners, and through inadequate control of bitter volunteers.

Once a sweet variety is contaminated, the bitter seeds cannot be removed without extensive plant breeding, and the seed should not be used for further sowing. If the contamination frequency is less than 1%, the seed is still suitable for sale or feeding to stock. **Bitter-free certified seed** should be sourced to ensure future crops are clean. Certified seed is tested over several generations using an ultraviolet (UV) lamp to ensure that no bitter contamination is present.

Bitter threat to the sweet albus industry

Commercial sweet albus crops grown in fertile conditions are usually very low in alkaloid. Values of

0.002% (or 20 mg/kg) are common. However, bitter seeds have an alkaloid level in the range 1.5–2.2%, that is 15 000–22 000 mg/kg, or 10 thousand times greater than their sweet counterparts.

If a crop of albus lupins has 99% sweet seed with 20 mg/kg, and 1% bitter seeds with 20 000 mg/kg, the overall alkaloid level would be about 220 mg/kg. This is above the acceptable Food Standard of 200 mg/kg for lupin alkaloids.

Pulse Australia's Receival and Export Standards for albus lupins specify that **bitter contaminants must be no more than 2 seeds/200 g**. With an average albus seed size of 0.35 g, that equates to a bitter seed frequency threshold of 1 in 285 seeds (0.35%).

Clearly, both the Food and Receival standards are at risk of being breached if sweet crops become contaminated at even very low frequency.

The future of the Australian albus lupin industry depends on the ability to supply 100% sweet seed. Considerable effort occurs in the albus breeding program to ensure that new varieties, such as the new high-yielding and disease-resistant Luxor and Rosetta, do not contain bitter contaminants.

In Europe, Chile and South Africa, where both bitter and sweet albus varieties are available to growers, it is not possible to guarantee 100% sweet crops. This has a serious impact on overall crop quality and compromises markets. If bitter albus types are grown in Australia, in the same geographic areas as sweet types, it is likely that contamination will occur. This contaminated seed may find its way into 'sweet' deliveries.

Crops of narrow-leaf lupin (*Lupinus angustifolius*) do not hybridise with albus, meaning they are not at risk of contamination themselves, and also cannot contaminate a nearby albus crop.

Markets for bitter albus lupins

The current domestic market for lupini bean is estimated at 500 tonnes per annum, while the overseas market is about 2000 tonnes – possibly rising to 5000 tonnes over time. These are relatively small volumes compared with the sweet albus industry, which was about 70 000 tonnes per annum in NSW in 1999 but has fallen in recent drought years. In better seasons, about 30 000 tonnes of the sweet crop is exported for the human consumption market. The balance of the domestic production is either fed to stock (sheep, cattle, dairy cows, chickens and horses – but not pigs) or processed for addition to foods. Hulls, for example, are used in bread as a source of vegetable fibre. The de-hulled kernels are high in protein and are being sold as feed for aquaculture.

While the growing of lupini bean has been on a small scale and well controlled, the push for farm diversification has meant that growers throughout NSW may be interested in trying lupini bean.

Only one variety of lupini bean, **Lago Azzurro**, is registered and protected under Plant Breeder's Rights legislation. Several other private varieties are known to be under cultivation, including **Mount Beauty** and **Murphy**. No new lupini bean varieties can be imported into Australia from overseas. Quarantine restrictions have been in place since 1996 to prevent the spread of anthracnose, a severe fungal disease which is established in Western Australia, where it has prevented albus from growing until resistant varieties can be bred.

If a lupini bean crop is grown but the harvested seed cannot be sold into the specialised human consumption market, it **must not** be fed to stock, or delivered or sold as 'sweet' seed, because alkaloid poisoning will probably occur.

Lupini bean isolation protocol

The growing of lupini bean in sweet albus areas should be strongly discouraged through industry and peer pressure. Litigation is possible should a sweet crop be contaminated by bitter pollen.

If lupini bean were to be grown, extreme care would need to be taken. It is important to isolate the sweet and bitter albus crops in order to maintain the purity of variety and quality, which appeal to their respective end consumers.

Protocols

If growers are considering planting lupini bean, it will be necessary to follow these protocols in order to avoid the contamination of sweet albus crops.

- Lupini bean must be grown at least 2 km from any sweet albus crop.
 - As a priority, all neighbours should be informed of the intention to grow lupini bean. A check should be carried out to ascertain whether neighbours are planning to grow a sweet albus crop within a 2 km radius of the lupini bean paddock.
 - Controlling volunteer lupini bean plants is essential, otherwise lupini plants may survive from year to year and be present in a paddock when the next sweet albus crop is sown. Hard grazing, cultivation and the use of knockdown herbicides will help control lupini bean volunteers.
 - Paddocks should be free of any volunteer lupini bean plants for a minimum of 2 years before considering a following albus crop.
- All sowing machinery and vehicles leaving a paddock sown to lupini bean should be inspected and thoroughly cleaned in order to avoid seed transfer to another paddock. Sow all sweet albus crops before sowing lupini bean.
 - Harvest machinery, transport equipment and storage vessels should be thoroughly cleaned with compressed air before moving to the next paddock. All sweet albus crops should be harvested before moving onto the lupini bean crops.
 - All personnel, including contract labour, leaving a lupini bean crop at sowing or harvest time must thoroughly clean their clothes and shoes of any lupini bean seeds.
 - Ensure silos are dedicated to lupini bean, thoroughly cleaned with compressed air, and kept separate from any sweet albus silo storage. Any spilt grain around the silos should be cleaned up and carefully disposed of. Burying at a depth of 1 m is a suitable long-term disposal method for discarded seed, bags and sacks.
 - Road transport of lupini bean must be carried out with loads covered and fastened tightly to avoid spillage, otherwise volunteer plants may occur on roadsides.
 - Seed processing should be undertaken by an accredited seed cleaner with a sound quality assurance system, to ensure varietal contamination does not occur. The seed cleaning contractor must be fully informed about the lupini bean seed lot, to ensure that the risk to sweet seed lots is minimised. When lupini bean has been cleaned in seed cleaning equipment, seed other than sweet albus lupins should ideally be the next seed cleaned in that equipment.

Industry control of bitterness in sweet albus crops

The albus industry has a management plan in place to reduce, and eventually eliminate, bitter contamination in sweet crops (see [Primefact 683, Testing albus lupins for bitter seeds](#)). All seed for sowing should be UV-tested. The contamination threshold for sowing in 2010 has been set at zero bitter seeds. The threshold has been set at zero for several years in an attempt to eliminate the problem. The rapid adoption of the new, improved varieties, Luxor and Rosetta, will assist in removing the contamination from the industry. Growers should isolate contaminated crops and plan to replace seed the following year.

Further reading

Gladstones, JS, Atkins, CA, & Hamblin, J (eds) 1998, *Lupins as Crop Plants: Biology, Production and Utilization*, CAB International, Wallingford, UK, ISBN 0851992242.

Pulse Australia website: pulseaus.com.au

[Food Standards Code](#) (1987 and as subsequently amended), [Food Standards Australia New Zealand](#), Canberra.

Further information

If you are considering growing lupini bean, then seek advice from the Industry & Investment NSW Lupin Breeding Program, Wagga Wagga (Phone (02) 6938 1999), or from your local [District Agronomist](#).

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