PULSES NUTRITIONAL VALUE AND THEIR ROLE IN THE FEED INDUSTRY

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INTRODUCTION

This booklet has been developed for both the producers of pulses (grain legumes) and the end-users in the domestic and on farm stockfeed industry. It is designed to be an introduction to the use of pulses in stockfeed diets. Market segments included are pigs, poultry, beef cattle, sheep, dairy and aquaculture.

This booklet has two objectives. Firstly to highlight the availability and nutritional value of pulses, and secondly to provide a guide to the market segments to be targeted by each pulse product.

The information contained is intended to provide a qualitative over view and analysis. The primary aim of this publication is to present an easy to understand guide to the benefits of pulses in stockfeed diets, key requirements of different market segments and nutritional factors. For those interested in more scientific information and detailed profiles of all pulse products, a further reference is *"The Chemical Composition and Nutritive Value of Australian Grain Legumes 1997",* as well as the *"Australian Livestock Feed Ingredient (ALFI) data base CD"* available from GRDC.

Information sources for this publication include nutritionists and end-users, farmers using pulses on farm, government agricultural officers, other advisers, and farmers supplying pulses to end-users and previously published information.

For users of pulses, this publication highlights the range of pulses grown in Australia, their geographic location and availability. For suppliers of pulses, the booklet highlights the key components of pulses which contribute positively to the market segments being targeted.

Pulse Australia would like to thank the Grains Research and Development Corporation for providing funds for this publication, and for funding in part their current field program. Thanks to all those who assisted by participating in the original and subsequent discussions and surveys.

KEY ISSUES WITH PULSES IN THE FEED INDUSTRY

The key to the long term balance of supply and demand within the stock feed industry is the development of strong lines of communication and longer term commitment between growers and end-users. It is critical for there to be end-user confidence so as to ensure a reliable, consistent and competitively priced supply of pulses as feed ingredients while growers must feel confident that there will be a sustainable market for their product.

Too often in the past an apparent lack of supply has stemmed from a perceived lack of market opportunity by growers. This has happened when overall supply is in fact sufficient, but is available only in small parcels that would need to be aggregated to become useful to the feed industry. Growers must work together, and in partnership with industry end-users to resolve such issues.

Growers must gain a more in depth understanding of the end-uses for the pulses they produce, and their priorities of use. They must also be aware of competitive alternatives to pulses that may be available to the stock feed market from other sources. They must consider the rotational benefits of pulse crops, and how they fit into their whole farm system, when assessing potential returns from pulse production for the price sensitive feed ingredient industries.

Growers should be aware that simple quality assurance programs on farm may be needed in future as end-users start to insist upon their suppliers complying with increasing demands for traceability.

End-users need to understand that many factors can influence grower decisions as to which pulse, if any, they grow. Reliability of market is paramount, but input costs, potential yield, price per tonne (nett dollar return), fit within the farming system, sowing date, weed issues and projected seasonal conditions are all considerations that may impact on supply in any given year.

Pulse Australia is working to provide a link between growers and the feed industry. Our aim is to maximise the value for the whole industry through better information flow and coordination along the value chain.

Photo: I. McNeil.

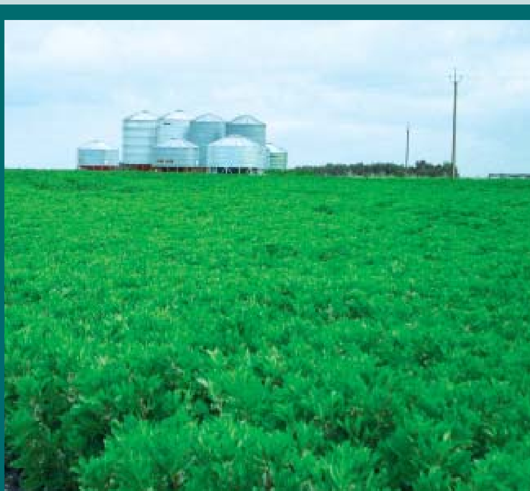

Photo: R. Ruwoldt.

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PULSES AS A FEED INGREDIENT

Currently the Australian stockfeed industry uses about 10 million tonnes of feed annually, with about 5.11 million tonnes processed by at least 101 manufacturing sites, and this is growing rapidly. Poultry, dairy and beef feedlots are major consumers accounting for 27%, 27% and 24% respectively. Pig production accounts for 16% (Stockfeed Manufacturers Council of Australia fact sheet 2004-2005).

Pulses have become an increasingly popular feed source in recent years with an estimated 10% to 20% of the diet comprising various pulses.

Field peas are the most widely used pulse in the intensive livestock industries although lupins are widely recognised as a superior feed source for ruminants. Other pulses such as faba beans, lentils and chickpeas are highly regarded as potential feed sources, but their use is somewhat limited because they have not been price competitive.

Current usage of pulses in the stockfeed industry is largely determined by regional production patterns, availability and the price of competitive alternatives (eg soybean meal). Geographic distance between production regions and the main domestic end-users tends to have a greater influence on cost and hence usage than simple preference based on nutritional value. Consistencies of supply and storage capacities also influence pulse usage.

On an equal price basis, peas are the preferred pulse in pig and poultry diets, followed by faba beans and lupins. However in ruminant diets, lupins are generally preferred due to their high protein content and their reduced risk of non-starch polysaccharides and anti nutritional factors.

In terms of regional dominance, the greatest proportion of lupins are produced and exported from Western Australia whilst the majority of peas and faba beans are produced in South Australia and Victoria. Northern NSW and southern Queensland are set to become significant producers of faba beans and field peas with the release of adapted varieties. The main concentration of domestic users for intensive livestock lies in the southern and eastern sectors of Australia and the cattle feedlot industry in the north of Australia. The dairy industry in south eastern Australia has become a major user of pulses, particularly lupins. Actual usage of each pulse type varies enormously between regions and from year to year dependant upon availability, the mix of crop species being fed and changes in the prevailing market conditions for grains and livestock.

A distinguishing feature of the Australian stockfeed industry is its preparedness to utilise a wide range of raw materials in response to market movements. There is very little reliance upon any particular commodity from one year to the next. For this reason, it is difficult to establish typical usage patterns or trends. End-users require sufficient quantities of product to start using that ingredient in their feed mix. Once committed to a product, changes are unlikely for reasons of diet consistency and storage capacities.

Corresponding to this is the ability for stockfeed diets to change very rapidly in response to price movements. Stockfeed diets, with the use of computerised linear programming methods, are highly specialised to provide the most cost effective and highest nutritional combination of feedstuffs. Thus, anyone in the livestock industry should seek advice in regard to quality and price factors when incorporating pulses into their diets.

In order to produce high quality fast growing animals (pigs, poultry, beef cattle or lambs), producers must pay attention to the feed requirements of their animals. Similar attention needs to be paid by dairy farmers to maximise milk production. Use of pulses can assist to achieve the animals requirements for optimum growth and performance.

The Australian aqua feed market is small, and may not reach significance. Provision of lupins into the sizeable international aquaculture feed market (12M t/year) is however increasing. Australian lupins are likely to be a very small segment of the international aquaculture sector, but there may be potential for high value lupin-based aqua feed ingredients.

Pulses are also used by graziers to supplement grazing sheep or cattle or to finish vealers and lambs. Usage of pulses in grazing and finishing systems is increasing as more growers and graziers appreciate the value of pulses in such systems.

Pulses are a high quality source of protein and energy for all forms of livestock, combining high levels of palatability and digestibility.

In formulated feeds the amino acid profile of pulses generally complements that of cereal grains with only small amounts of limiting amino acids, usually methionine and sometimes lysine, needing to be added or drawn from alternative protein sources to give a balanced diet. Absence of any chemicals or residues is important. Quality Assurance (QA) programs are increasingly providing security against residues.

Table 1 provides a nutritional comparison of pulses with the common protein source, soybean meal.

PULSES AS A FEED INGREDIENT

Table 1. Proximate composition (% air-dry basis), energy content (MJ/kg air-dry basis) and essential amino acid content (g/16 g N) of legume seeds or meal.

Component	Chick pea	Faba bean	Field pea	N-L lupin	Albus lupin	Yellow lupin	Mung bean	Navy bean	Peanut meal	Pigeon pea	Soybean meal
Crude protein	19.5	23.1	23.4	28.9	35.8	38.3	23.9	22.7	47.4	18.3	46.7
Dry matter	89.1	90.6	90.7	89.7	91.4	91.5	89.8	89.7	91.5	88.8	89.1
Crude fibre	7.0	6.9	6.1	13.0	10.6	16.3	3.9	4.2	13.1	10.5	5.2
Ether extract	3.9	1.2	1.2	5.4	9.4	5.6	1.3	1.5	1.2	3.3	1.2
Ash	2.9	3.2	3.0	2.8	3.3	3.5	3.7	4.1	4.5	4.5	5.9
Nit-free ext	55.7	56.3	57.0	40.2			57.0	57.2	25.3	52.2	3.01
Energy#											
DE - Pig	16.2	13.7	14.4*	14.2	16.9	16.4	15.6	15.6	11.9	13.5	14.0
ME - Cattle	12.1	13.1	11.3	12.0	11.9	15.3	11.4	11.3	10.6	8.0	11.1
ME - Chick	12.2	11.2*	11.5*	8.9			10.5	9.7	9.2	-	9.3
ME - Pig	14.8	12.9	14.1	-			14.1	14.2	10.2	12.4	11.9
ME - Sheep	11.5	11.5*	12.0*	12.2			11.7	11.7	11.5	8.9	12.0
AME - Poultry		11.2	11.5	10.7	13.2	11.5					10.7
Threonine	3.3	3.5	3.8	3.4	3.3	3.5	3.2	4.5	2.7	3.9	4.0
Valine	3.5	4.4	4.7	3.6	3.7	3.4	6.0	5.2	4.0	4.1	4.6
Methionine	1.0	0.8	0.6	0.6	0.7	0.7	0.8	0.7	0.7	0.8	1.1
Isoleucine	4.2	3.8	4.3	3.9	3.8	3.7	4.8	4.6	3.4	3.8	4.5
Leucine	7.4	7.3	7.8	7.5	6.3	7.9	7.2	8.3	6.8	7.1	7.7
Phenylalanine	5.2	4.1	4.6	3.7	3.4	4.0	4.8	5.8	4.9	8.4	4.8
Histidine	2.5	2.5	2.7	2.7	1.9	2.7	2.0	2.8	2.2	3.3	2.7
Lysine	5.8	6.2	7.3	4.7	4.3	5.4	6.8	6.9	3.3	5.8	6.0
Arginine	9.8	9.4	10.3	10.2	12.2	11.3	6.0	6.7	12.8	6.2	7.4
Tryptophan	0.64	0.7	0.83	0.60	1.0	0.78	1.8	1.7	0.83	0.74	1.03

 # DE is digestible energy, ME is metabolisable energy. Source: Batterham and Egan (1987);
** van Barneveld et al. (2000) via Edwards (2004); Petterson et al. (1997).*
B. Mullan and K. Jae Cheol personal communication.

It is crucial to have feed analysed prior to ration formulation. Protein in pulses can range between 18% and 36% and hence the content of amino acids such as lysine can also vary. Levels of all nutrients can vary depending on the variety, location and growing conditions.

Since pulses supply both energy and protein to the diet, their value is influenced by cereal price differentials (wheat versus barley versus oats), cereal protein content, the price of tallow or oil, as well as the cost of alternative proteins (e.g. soyabean meal, canola meal, meat meal, blood meal, fish meal). Pulses compete for a position in animal feeds against a full spectrum of diverse materials which are constantly changing (Edwards 2004).

The publication by Petterson, Sipsas & Mackintosh (1997) titled *The Chemical Composition and Nutritive Value of Australian Grain Legumes edition 2* provides detailed nutritional profiles for all Australian pulses.

Field Peas (Pisum sativum)

Field peas are a good protein source with a good profile and balance of amino acids. Subject to price, peas can be one of the more favoured pulses in the stockfeed industry due to:

- good protein quality and high amino acid availability;
- good digestibility and high energy content;
- low level of anti nutritional factors;
- ease of storage and milling;
- relatively consistent composition; and
- low hull/endosperm ratio and therefore minimal processing.

The metabolisable energy content of peas for ruminant animals is high (11.7 – 12.0 MJ, similar to lupins). The fat content of peas is very low, as are the levels of fibre and lignin, whilst the content of soluble carbohydrates (mostly starch) is high.

Utilisation of energy by non-ruminant animals is fairly high since most of the energy yielding components are digested in the upper intestinal tract.

Pea hulls are high in poorly digestible fibre for monogastrics and whilst dehulling would improve the utilisation of energy by non-ruminants, this is unlikely to be cost competitive. White seeded peas have lower tannins than the dun types.

Protein content of peas is about 230g/kg and there are similar constraints to lupins on quality from low tryptophan and methionine levels, although the lysine content is higher. Inclusion of peas in the diet results in reliable performance due to the close agreement between amino acid digestibility and availability.

Peas are an excellent source of protein for pigs, often representing a cheap source of available energy and lysine in cereal-based diets. They do not require processing prior to feeding. Commercial pig producers use up to 40% seed in their formulations and obtain good feed conversion. Poultry diets can contain up to 25% to 30% peas with little risk of wet droppings.

Field Pea Grain – Dun, White and Green

Narrow-Leafed Lupins (Lupinus angustifolius)

Narrow-Leafed Lupins

Narrow-leaf lupins are widely accepted, and are the most universally used pulse, partly because they are generally the most economical. Lupins are preferred due to the availability of free amino acids, at competitive prices to balance their high protein content, combined with easy storage and geographic availability. Price may be influenced by grazier demand in some areas.

Lupins are primarily consumed for their high protein content. The protein is of reasonable quality, they can be used without pre-treatment and have a high digestibility in all species.

The cellulose hull of lupins is of limited value to monogastrics, especially poultry, yet is a readily digestible fibre source for ruminants. As such, dehulling provides a means of improving the utilisation of lupins by allowing kernels to be directed to monogastric diets and hulls to ruminant diets, where they are both well utilised.

Narrow-leafed lupins are now widely accepted throughout Australia as a supplement for ruminants because they are high in available energy and protein and have advantages in handling, storage and feeding. They are especially useful to feed sheep in times of pasture shortage and as part of a production strategy.

Lupins are also widely used in pig and poultry nutrition where they are valued for their consistent quality and low content of anti nutritional factors. For pigs and poultry, lupins require supplementation with synthetic methionine and lysine. Enzyme supplementation may also expand the opportunities for lupins in pig and poultry diets through improving utilisation of non-starch polysaccharides to facilitate their breakdown to sugars in the small intestine.

Commercial pig producers have successfully used up to 30% whole narrow-leafed lupin seed in pig diets. Poultry diets normally contain less than 10% lupins, frequently kernels, because of the problem of ‘sticky’ or ‘wet’ droppings.

All components of narrow-leafed lupin grain are readily digested by ruminant animals. A big advantage of lupins is that ruminants do not need a period of introduction to avoid acidosis, due to the absence of starch. Furthermore, the amount of lignin, the compound that usually limits the digestion of fibre, is very low (<1%) so that the overall digestibility of lupin seed is high (about 90%). Non-ruminant animals lack the enzymes responsible for digesting the complex carbohydrates in the stomach and small intestine.

In ruminant animals the composition of the protein is of less importance, although the content of methionine may be limiting for wool production in sheep and milk production in high producing dairy cows. A proportion of dietary protein is undegraded in the rumen and can increase the supply of protein to the animal. Hence, increasing the overall nutritive value of feeds. In narrow-leafed lupins up to one third of the protein is undegraded in the rumen and much of the response to lupin seed supplements in sheep and cattle reproduction has been attributed to this undegraded protein portion. The ability to introduce stock quickly onto lupins with no acidosis problems is a key positive attribute.

There is little need for processing of lupins for feeding to sheep, but cracking or milling whole seed is advisable for cattle, especially dairy cows. For cattle and sheep, lupins allow a high energy diet without giving rise to acidosis.

Narrow-Leafed Lupins Flowering

Albus Lupins (Lupinus albus)

Albus lupin grain has a higher protein and crude fat content than narrow-leafed lupins. For pigs and poultry, albus lupins provide considerably higher levels of dietary energy concentration. Energy value is higher and digestibility is similar, for some animal species. If included at more than 15% of the diet there is poor acceptance of albus lupins by pigs causing depressed intake and lowered growth rate. Accumulation of manganese and the low methionine levels in albus lupins were initially blamed, but these factors have now been discounted. Further research is required to establish the reasons for depressed intake.

Albus lupins have a higher protein and oil content as a consequence of less seedcoat (15%) compared with narrow-leafed lupins (25%) and field peas (9%).

Yellow Lupins (Lupinus luteus)

Yellow lupins have a higher crude protein and lower crude fat content than narrow-leafed or albus lupins. The yellow lupin protein has higher levels of S-containing amino acids. Energy value is higher and digestibility is similar for pigs and poultry. When de-hulled, the yellow lupin kernel is a very concentrated form of vegetable protein. Poultry, pig and aquaculture industries indicate that yellow lupins would be a preferred product over narrow-leafed or albus lupins. If included at 20% of the diet there is good acceptance of yellow lupins by pigs. At 20% of the diet, yellow lupins produce similar growth rates in pigs to Soybean meal (Mullan 2001).

Yellow Lupins Flowering

Yellow and Albus Lupins

Pearl Lupins (Lupinus mutabilis)

The pearl lupin is being developed in Western Australia as a new lupin species with higher oil content, higher crude protein and higher crude fat content than existing lupin species. It is not yet commercially available, but research continues.

Dehulled Lupins (all species)

Because of varying seed coat percentages in the various pulses, there are considerable differences in the available energy content between whole seed and kernel meal. Whilst dehulling lupin seed can improve the utilisation by non-ruminants, the hulls and other particles removed during the process can be satisfactorily pelleted to make a complete feed for sheep, or incorporated into formulated feed for ruminants.

There is some potential to further develop lupin-based aqua feed ingredients in the higher value international aquaculture markets (see section: Usage of Pulses by Market Segment - aquaculture).

Table 2: Whole versus dehulled attributes for the different lupin species.

Chemical composition of whole lupin seed and kernels*								
Species	**Narrow-leafed lupin**		**Albus lupin**		**Yellow lupin**		**Pearl lupin**	
	% wholeseed	% kernel	% wholeseed	% kernel	% wholeseed	% kernel	% wholeseed	% kernel
Seed coat	24	0	18	0	27	0	16	0
Moisture	9	12	9	11	9	12	8	10
Protein	32	41	36	44	38	52	43	52
Fat	6	7	9	11	5	7	15	17
Ash	2	3	3	4	3	4	3	4
Lignin	1	1	1	1	1	1	1	1
Polysaccharides	22	29	17	21	8	11	9	10
Oligosaccharides	4	6	7	8	9	12	5	6
Minor components	0.5	1	0.6	1	0.9	1	1	1
Total sum (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Available energy contents# MJ/kg								
	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg	MJ/kg
ME *cattle*	12.0	15.0	11.9	14.0	-			
DE *pigs*	14.6	18.3	16.9	19.9	16.4			
AME *poultry*	10.7	13.4	13.2	15.5	11.4			
Protein and sulphur amino acids (g/kg)**								
Cysteine+Cystine	6.2	-	7.4	-	11.5	-	9.6	-
Methionine	2.0	-	2.4	-	2.7	-	2.8	-
Total S-aa's	8.4	-	9.8	-	14.2	-	12.4	-

*# DE is digestible energy, ME is metabolisable energy. * Source: S. Sipsas, Department of Agriculture WA.*
*** Source: S. Sipsas Perth GRDC Update paper Feb 2004 (by Barkolt and Jensen 1989 method).*

Albus Lupin Grain and Kernels

Faba and Broad Beans (Vicia faba)

Faba beans have a lower critical nutrient content than peas, more crude fibre and possibly lower levels of tannins and vicine. Low levels of faba beans (10-15%) have performed well in pig and poultry feed production.

Gross energy content of faba beans, about 16.8MJ/kg, is typical for pulses of low oil content. The high digestibility of its components results in a metabolisable energy for pigs, poultry and ruminants similar to those for lupins, field peas and soybean meal.

There is a significant negative correlation between the *in vitro* digestibility of faba bean protein and the tannin content of the seed. Tannins are mostly located in the seed coat (hulls) and dehulling can increase protein digestibility and increase in feed conversion efficiency. Supplementation with methionine, and probably tryptophan, is advisable.

Faba beans can be an effective protein source for poultry provided the amino acid shortfalls are balanced.

Broad beans are basically the same as faba beans, except for their larger seed and that their protein content may be slightly lower than faba beans.

Faba and broad beans play a valuable role in the supplementation and finishing role in sheep and cattle, the larger grain size being a valuable attribute.

Faba Bean Grain

Chickpeas (Cicer arietinum)

Chickpeas, both desi and kabuli types, are relatively low in anti nutritional factors, have high protein digestibility, and are richer in phosphorus and calcium than other pulses. With their high fat content and high fibre digestibility, chickpeas are useful as a protein and energy source for ruminants and non-ruminants, and the residual stubble after harvest has good forage value. Fibre content is lower in kabuli chickpea types than in desi's.

Chickpea grain prices are generally higher than feed grain prices because they are exported to human consumption markets. Chickpeas that enter stockfeed markets are generally grains that have excessive seed discolouring from weathering or disease, or are physically damaged by insects or handling.

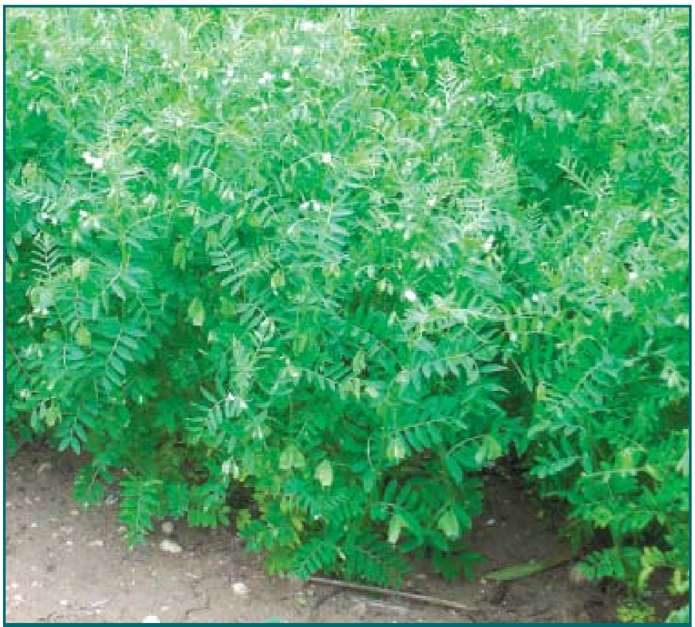
Chickpea Crop

Desi Chickpeas

Kabuli Chickpeas

Lentils (Lens culinaris)

Lentil grain that enters stockfeed markets is usually shrivelled, discoloured from weathering or disease, or physically damaged by insects or handling. This is because premium prices for export human consumption markets are the main target for sound lentil grain.



Lentil Crop

Lentil Grains

Grain or Common Vetch (Vicia sativa)

Grain vetch for ruminants is considered similar to field peas, but much smaller in size. Grain vetches are not generally recommended for monogastrics, and are not widely available. There is potential for contamination by wild vetches (tares) or other commercial vetch species (V*icia benghalensis or V. dasycarpa*) with higher anti-nutritional factor contents.

Narbon Beans (Vicia narbonensis)

Narbon beans are not recommended for monogastrics because of poor palatability, but are considered similar to field pea grain in ruminant diets. Supply is extremely limited.

Lathyrus: Dwarf Chickling (Lathyrus cicera), Grass Pea or Narrow-Leaf (Lathyrus sativus)

There is evidence that Lathyrus is a suitable grain for ruminants, but use in monogastrics should be treated with caution. Grain supply is extremely limited.

Bitter Vetch (Vicia ervillia)

There is evidence that bitter vetch is a suitable grain for ruminants, but use in monogastrics should be treated with caution. Grain supply is extremely limited.

Photo: Dept. of Ag. W.A.

Photo: Dept. of Ag. W.A.

Table 3. Proximate composition and energy content of minor legume species in comparison to Field Peas.

Component	Field pea*	Common vetch*	Narbon bean*	Dwarf chickling**	*Grass pea#*	*Bitter vetch**
Crude protein %	23.2	27.8	24.2	24.1	27.3	21.8
Ash g/kg	24.9	24.9	27.7	28	24	25.6
Fat g/kg	11.2	8.6	7.6	6	15	12.3
Crude fibre g/kg	59.4	51.0	115.3	63	73	51.0
ADF g/kg	93.3	74.6	142.6	96	85	
NDF g/kg	132.6	219	287.6	219	142	
Lignin g/kg	5.3			2	11	
Oligosaccharides %	3.53	3.45	3.37			
Phytate %	0.59	0.66	0.74	0.81	0.5 - 1.1	
Tannins %	0.37	0.64	0.72	0.46	0 - 0.8	
TIA mg/g	1.29	2.40	0.29	0.19	1.7 - 4.4	
CTIA mg/g	1.60	2.25	2.05	0.31	0 - 2.3	
Lectins dilut	4.00					
Energy MJ/kg##				18.7	19.0	
GE	18.8	18.7	16.2			
DE - sheep	-	16.0	-			
DE - pigs	14.5	-	-			
ME - sheep	11.4	12.0	-			
ME - poultry	-	-	12.0			
AME - poultry	11.5	-	-			

** Source: Petterson et al (1997) ** Source Handbury and Hughes (2000, 2003) # Source Farhangi et al (1996). B. Mullan and K. Jae Cheol personal communication. ## GE is gross energy, DE is digestible energy, ME is metabolisable energy.*

USAGE OF PULSES BY MARKET SEGMENT

Pulses have become increasingly popular as a livestock feed source or compounded feed ingredient due to their nutritional value and because they are cost effective. Pulses provide the additional benefit of widening the range of ingredients available to the feed industry.

According to Australian Bureau of Statistics data on agricultural enterprises in 2005, there were 9,881 dairy, 882 pig, 666 meat poultry, 423 egg producers, and 17,195 grain-sheep/beef enterprises. There were 12,719 grain growers.

Poultry

Narrow-leafed lupins and field peas are the most commonly used pulses in poultry diets. Pulses will be included from 5% to 30%, with most users including 10% to 15% in diets when priced competitively. This varies between type and age of poultry.

Key nutritional characteristics are protein, energy and essential amino acids. Field peas provide the best combination of amino acids.

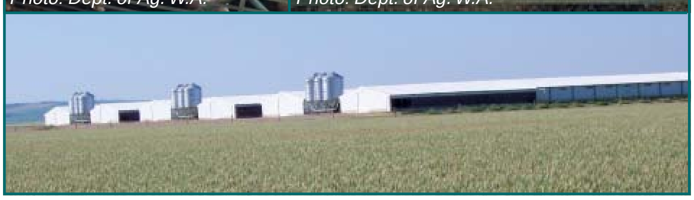
In breeder and young layer diets, pulses (primarily lupins and field peas) are replacing meat meal or soybean meal. For layers the protein/energy combination of pulses is important. Lupins and peas are readily used due to their availability, and to reduce the requirement for more expensive meat meal.

Albus lupins for poultry provide considerably higher concentrations of dietary energy than narrow-leafed lupins. The major issue with albus is its availability and lack of knowledge about it. A maximum inclusion of 10% in broiler diets is suggested from research. It is however unlikely that albus lupins would be treated any differently or segregated from narrow-leafed lupins by users.

Feeding Dwarf chickling *cv.* Chalus to layer hens for 32 weeks had no negative effects at up to 30% of diet (Handbury and Hughes 2003). Longer term feeding studies were considered to be warranted in broiler chickens and layer hens to determine any adverse effects in eggs, chicken meat and excreta.

Photo: Dept. of Ag. W.A.

Photo: Dept. of Ag. W.A.



Pigs

The most used pulses in this market segment are peas and narrow-leafed lupins. Key nutritional characteristics of pulses for pigs are: proteins, amino acids, energy and fibre. For amino acid, energy and protein requirements, field peas provide the best alternative at similar price levels; however protein and energy are contributed by all the pulses including lupins, faba beans, chickpeas and mung beans.

Maximum inclusion of pulses in the diet varies between 5% and 30%, and usage varies with age of stock. For example, from the Australasian Livestock Feed Ingredient (ALFI) data base:

- 10% maximum inclusion of narrow-leafed lupins in smaller pigs (weaners) where digestibility is less, 30% maximum lupins in grower pig diets, and 20% maximum lupins in sow or finishing pig diets.
- 15% maximum field peas in young pig diets and 40% maximum field peas for other pig diets because of anti-tryptic factors.
- 10% maximum chickpeas in smaller pig (weaners) diets, but 30% maximum inclusion of desi and kabuli chickpeas for all other pig classes
- 15% maximum faba beans in starter pig diets, 20% in growing or finishing diets, and 15% in breeding stock.
- Common vetch is not recommended for young animals, but can be included with caution at levels up to 35% when fed to 35-40kg pigs without depressing performance.

Albus lupins provide considerably higher levels of dietary energy than narrow-leafed lupins, but can have adverse effects on feed intake in pig diets. They are however used at no greater than 5% inclusion. There is a need for research to understand the constraint to albus lupins in the pork industry.

Yellow lupins have potential to be a high quality feedstuff for growing pigs, with a maximum inclusion level of 180g/kg suggested for pigs between 20 and 55kg live weight.

USAGE OF PULSES BY MARKET SEGMENT

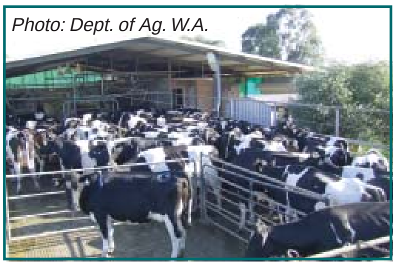
Beef Cattle


Photo: Dept. of Ag. W.A.

Lupins tend to be the most used pulse although this segment is more flexible with a large diversity of products being used. Maximum inclusion for pulses is limited by price, but varies between 5% and 40% with most including at least 20% pulses.

Key nutritional characteristics sought are protein (rumen de-gradable as well as bypass) and energy from fermentable fibre rather than starch. The ability to introduce cattle onto lupins quickly is a key positive attribute.

Dairy

Photo: Dept. of Ag. W.A.


Lupins are the main pulse used by dairies substantially because of their ability to enhance milk production and quality. Maximum inclusion for pulses varies for 5% to 30% with most around 10% to 20%. Key nutritional factors are protein, energy and fibre.

Sheep

Lupins are the most significant pulse used. However, the major constraint is cost, not nutritional requirements. Lupins can constitute up to 100% of the supplement. Maximum inclusion in formulated sheep diets is at least 40%. Key nutritional characteristics are protein, energy and fibre. The ability to introduce sheep onto lupins quickly is a key positive attribute.

Feeding of other pulses to sheep is possible, but more limited because they can be more expensive, provide less protein, and have higher starch. Hence requiring a longer introduction period than lupins and could have more associated acidiosis issues.

Lupins are easy to feed out, require no introductory trial period and are easy for sheep to pick up from feed trails or when broadcast into stubbles or on pasture. The high energy content and wide range of areas where they are grown are further advantages. Frequently lupins are the sole supplement for grazing sheep in summer and autumn.

Lupins are mostly used for production feed, that is, growing lambs and pregnant ewes, and can be fed strategically to promote fertility. Feeding lupins to lambs while still with the ewe (imprint feeding) is an important step to finishing lambs on a lupin diet.

Drought Feeding

Pulses, particularly lupins, field peas and faba beans often have a major role when graziers are feeding maintenance diets to their livestock in drought times. Pulse grains and baled stubble residues are valuable components of drought feeding diets, either alone or in combination with cereal grains.

Aquaculture

Lupins are the most significant pulse used in aquaculture, and export sales are increasing. The CBH group in Western Australia has increased sales to the aquaculture sector from 100 tonnes in the year 2000 to 40,000 tonnes in 2005.

There is potential to further develop lupin based aqua feed ingredients in higher value international aquaculture markets. Lupin kernel meals have some significantly different features compared with competitor products like soyabean meal.

Examples are: the functional properties of extruded aquaculture pellets with enhanced density and oil absorption; improved salmonid digestibility of protein; and high dietary fibre.

There is no difference between yellow, albus or narrow-leafed lupin kernels in the digestibility of key nutrients (Glencross *et al* 2004) in aquaculture. Yellow lupins provide equal and possibly better commercial benefits than angustifolius lupin (Glencross 2001).


Photo: Fisheries Dept. W.A.

POSSIBLE ANTI NUTRITIONAL FACTORS

Field Peas

Field peas are relatively low in anti nutritional factors compared to dry edible beans (*Phaseolus vulgaris*) or soybeans and are easily manageable, It is not considered necessary to use heat treatment prior to inclusion in formulated feeds. Occasionally pigments which cause yellow skin in broilers may occur (as with corn) and can reduce the level of inclusion in broiler diets. This colouring could be an advantage in layer diets if translated into eggs that are more yellow. Anti-tryptic factors are of no practical significance.

Faba Beans

Bean cultivars grown in Australia tend to have low tannin in their seed coats. Tannins could be a problem for utilisation of protein. Dehulling seed easily overcomes any problems with tannins. Any untoward effect from trypsin inhibitors or proteinaceous anti nutritional factors can be overcome by extrusion or cooking. Do not store ground faba beans for more than a week to avoid rancidity.

Higher fibre levels can reduce protein digestibility.

Australian bean cultivars tend to have low vicine and covicine levels. Vicine and covicine are of no consequence to pigs and broilers, but may affect laying hens by reducing the egg quality and fertility. Low vicine cultivars in layers' diets will overcome these effects.

Lupins

Narrow-leafed, albus and yellow lupins contain low levels of several common anti nutritional factors, but unlike whole soybeans and some other pulses, do not require heat treatment to destroy the lectins and protease inhibitors which can reduce protein digestion and availability.

Australian lupins are "sweet", with low alkaloid levels. Alkaloids are not a problem in current narrow-leafed varieties although the incidence of alkaloids in bitter contaminants or older varieties has caused digestive problems. National lupin receival standards have set maximum levels of bitter contaminants. There is an industry protocol in place to ensure that bitter contaminants with high alkaloid levels do not increase and become a concern in albus lupins.

High fibre content in lupins reduces energy and may cause wet droppings in poultry if used at high levels of inclusion. However, this may be offset by use of enzymes or if lupins are included at lower levels.

Poor acceptance of albus lupins by pigs and lowered growth rate occur if included at more than 15% of the diet. Two possible explanations for low feed intake and subsequent reduced performance in pigs fed albus lupins are either:

(i) increased retention time in the stomach of pigs fed albus lupins limited feed intake (Dunshea *et al* 2001) or;

(ii) pigs may be more sensitive to the completely different alkaloid profiles between albus and narrow-leafed lupins. Pigs do not tolerate more than 0.012% alkaloids of albus lupins, whereas young pigs can consume diets containing up to 0.045% of alkaloids from yellow lupins without any negative effect on feed intake (Buraczewska et al 1993).

Chickpeas

Desi and kabuli chickpeas are low in anti nutritional factors, although trypsin inhibitor limits the inclusion of chickpeas at high levels. Excessive amounts may cause digestive problems. However, trypsin inhibitor and tannins appear to be of no concern to pigs at up to 70% inclusion levels.

Vetches

Some vetches contain neurotoxins, mainly BCA (beta-cyanoalanine) and other anti nutritional factors. Hence vetches can only be used in limited quantities for monogastrics, and contamination by wild vetches (tares) or other species may exacerbate the problem. Inactivation of BCN by autoclaving does not improve the digestibility of amino acids or digestible energy.

Vetch Grain

POSSIBLE ANTI NUTRITIONAL FACTORS

Lentils

Lentils are low in anti nutritional factors.

Narbon Beans

Narbon beans contain the sulphur compound gamma-glutamyl-S-ethenyl-cysteine (GEC) which severely reduces grain palatability and leads to reduced feed intakes in monogastrics.

Narbon Beans have some minor use as a rotational crop or grain for ruminants

Lathyrus: Dwarf Chickling (Lathyrus cicera), Grass Pea or Narrow-Leaf (Lathyrus sativus)

Excessive intake of lathyrus by pigs or poultry can cause lathyrism. The neurotoxin 3-(N-0xalyl)-L-2,3-diaminopropionic acid (ODAP) is less in *Lathyrus cicera* compared with *Lathyrus sativus* (grass pea).

Lathyrus has minor use as a rotational crop or grain for ruminants

Bitter Vetch (Vicia ervilia)

Anti-nutritional factors in bitter vetch include L-canavanine, trypsin inhibitor, catechin and a special lectin. The bitterness in bitter vetch needs to be removed by leaching with boiled water before it could be considered for humans or monogastrics.

Bitter Vetch

Other Pulses

Navy beans contain lectins and are only used in limited quantities, unless processed using heat treatment. Once processed to denature the lectins they represent good feed value.

WHAT PULSES REPLACE IN THE FEED DIET

Pulses replace or compete with both protein meals and other grains as they supply protein and energy. The extent of replacement is based largely on price. Feed manufacturers use computer models to determine least cost diets or ‘cut-off’ prices for ingredient inclusion in diets.

Pulses in sheep and cattle diets are primarily used as an additive to cereal grain supplements/diets to achieve the desired balance between energy, protein and costs. In feed formulations for ruminants, pulses tend to replace oilseed meals to contribute bypass protein.

Similarly in pig and poultry diets, pulses replace cereal grains and oilseed meals.

Any impact that potential future bio-fuel production may have on the feed grains and livestock industries is yet to be fully established. Growth in the bio-fuel industry may result in more cereal or oilseed crops being grown to supply new plants, particularly in regions geographically close to them. This would impact negatively on pulse areas sown.

Growth in the bio-fuel industry could also put pressure on grain prices through supply and demand imbalances. Waste products from both biodiesel and ethanol production are likely to be used in the livestock industry if prices are attractive, and so compete in rations with pulses. Intensive livestock enterprises can be anticipated to expand in areas close to new bio-fuel plants to capitalise on this by-product supply, which may provide opportunities for increase in the use of pulses to balance protein requirements of those enterprises.

PHYSICAL AND CHEMICAL CONTAMINANTS

Feed grains should not contain chemical residues (outside of approved MRLs), moulds, mycotoxins, and weed seeds, including natural toxins such as pyrrolizidine alkaloids (see van Barneveld 1999). National receival standards for pulses in Australia are designed to ensure that the risk of these contaminants is minimised. For more information see **www.pulseaus.com.au/standards**

Quality Assurance schemes are designed so that end-users can purchase product with confidence. The Stock Feed Manufacturer's Council of Australia (SFMCA) has introduced a compulsory FeedSafe® quality assurance accreditation programme for the Australian Stock Feed Industry, aimed at meeting the minimum quality standards defined with the Australian Code of Good Manufacturing Practice (GMP).

Chemicals used on farm in pulse production are required to be registered, or to have a permit available for their use. Maximum residue level (MRL) studies and adherence to withholding periods are required to obtain product registration or a permit for its use through the Australian Pesticides and Veterinary Medicines Authority (APVMA) **www.apvma.gov.au**

Chemical contaminants may have an effect on livestock production efficiency and grain nutritional quality. End-users need to establish priorities for residue management strategies after evaluating the risk to livestock from chemical contaminants such as herbicides, fungicides, insecticides used during growth and at both pre-harvest and post harvest. Chemicals of highest priority to avoid in a residue management strategy include bifenthrin (synthetic pyrethroid), chlorpyrifos-methyl (organophosphate), deltamethrin (synthetic pyrethroid), endosulfan (organochlorine), and fenitrothion (organophosphate) (Van Barneveld 1999).

Growers should also check with their client to ensure that their grain meets any specific requirements for supply that the end-user might have for chemical maximum residue levels.

The effects of moulds and mycotoxins are rarely widespread, and the potential risk these contaminants pose to livestock industries in Australia needs to be put in perspective (Van Barneveld 1999). The economic impact of moulds and mycotoxin contamination is difficult to assess because of a lack of systematic surveys and varying livestock production responses to the presence of these compounds. There is however much research and literature available on the effects of mould and mycotoxin contamination of grain on livestock production, and techniques available for their measurement (Van Barneveld 1999).

Weed seeds and the toxic components of weed seeds are still common contaminants of Australian grains used in livestock feeds, and can be responsible for significant livestock losses (Van Barneveld 1999). Purchasers and growers should observe the national pulse minimum receival standards. Growers should also check with their client to ensure that these receival standards do meet any particular processor, local or state requirements for supply. Where product is outside such particular specifications, weed seed contaminants must be identified and quantified, and any potential end-user advised prior to sale.

Poor quality sample of lupins

WHY GROW PULSES – PULSES IN THE FARMING SYSTEM

Pulses fit very well into farming systems and crop rotations because of their disease control, weed control, soil fertility, timeliness and financial benefits. They are a cash crop with important additional rotational and whole farm system benefits, including fitting into grazing systems. When grown in rotation with cereals, they have the advantage of providing an alternative income, even though the price of the feed grain is often lower compared with other human consumption pulses.

Numerous publications have demonstrated the value of pulses in crop rotations. Recent examples are; Northern Grain Productio - a farming systems approach (Lucy *et al* 2005) and the Grain Legume Handbook (2006 updates) for southern areas.

Pulses provide weed control alternatives that can enhance grain production in the whole farm rotation. This includes enabling herbicide groups to be rotated, and often enabling a crop-topping option to prevent the seed set of herbicide resistant ryegrass. They help maintain or improve available soil nitrogen by fixing much of their nitrogen needs rather than extracting it from the soil. Cereal yields following pulses are often significantly increased, and production costs are reduced with lower fertiliser nitrogen inputs on cereals and oilseeds being required. There is less cereal disease because pulses assist in the control of cereal root diseases, provided grass weeds are controlled.

Pulses fit well into modern farming systems, particularly where minimal or no tillage farming is practised and where a cereal stubble retention system is in place. Erosion risks are minimal in pulses grown with no tillage and standing stubble situations. Lupins and beans are sown early in the cropping cycle, and can be sown into dry soil. Pea, lentil and chickpea sowing is often delayed relative to cereals, with weed control and timeliness benefits. Beans and chickpeas can be deep sown into stored moisture in northern farming systems when sowing rains are not timely.

There is a potential role for growers to collectively negotiate supply to an end-user, form cooperatives, or use grain traders or grain brokers to parcel significant pulse tonnages to satisfy the end-user's regular supply needs. This becomes particularly important when there are many growers who are each storing small quantities of pulses on their farms.

In some areas there is potential for businesses to establish storage facilities to enable compilation of pulses and regular supply to end-users through the season.

PRICING PULSES

Nutritionally, pulses fit very well into animal diets, although individual pulses have different applications for specific livestock groups. The decision to use pulses in the diet is usually an economic one.

End-users utilise 'least cost ration' computer models to determine diet components and the price they can pay before an alternative component becomes viable.

In establishing a dollar value for pulses, producers must take into account the nutritional content of the pulse. An economical price to pay for pulses will depend on the price of alternate energy sources such as cereals, as well as the price of alternate protein sources, such as oilseed meals and animal protein meals (e.g. meat meal, soybean meal, fish meal and blood meal). Export price opportunities can also set the farmer price, particularly for lupins, peas and faba beans.

A strong Australian dollar impacts by reducing the import price of alternative protein products like soybean meal, and at the same time also reduces the Australian export price of our pulses.

Despite variation in prices and the energy adjustments, growing pulses for the feed market can be financially rewarding. Additional to whole seed use, livestock can make use of cracks, splits and other low fibre by-products of harvest.

A strong, consistent domestic feed market for pulses can benefit both livestock producers and pulse growers. Livestock producers can utilise pulses to decrease diet costs whilst pulse growers benefit from a stable market for their product. When used either alone or in a blend with oilseed meal, pulses are an excellent source of protein and energy for livestock. Their ability to fix nitrogen in the soil to improve subsequent crop yields and their effectiveness in extending crop rotations provides positive benefits for growers. Pulses provide alternative income opportunities for grain growers and offer livestock producers an alternative domestic protein source.

The main constraints limiting extended use of pulses in feed diets are price, reliability of supply, storage capacity, and limits on inclusion rates. Prices are very volatile and dictated by conditions in export markets, particularly the sub-continent. For example, any gains made by peas in the stockfeed market would to some extent be at the expense of beans and lupins.

Price competitiveness is critical to extended use but also to availability. An increased understanding of the nutritional benefits will assist to expand use. World prices of pulses for feed and food markets can influence the domestic price set, and hence the uptake or availability to the local feed industry. Prices of cereal grains and of competing protein meals all have an impact on pulse inclusion rates in livestock diets.

There is a significant opportunity for growers of pulses and the stockfeed sector to work more closely together to better target pulses for particular livestock segments and to stabilise prices for growers. This could result from improved and regular communication between the two sectors. If the livestock industry signals their requirements for specific qualities and quantities, then growers can undertake to supply over a period of time.

INFRA-STRUCTURE NEEDS FOR PULSES

There are often price benefits to be gained from storing pulses on farm or in commercial storage facilities compared with selling straight off the harvester.

There are also major benefits to both the producer and end-user if large parcels of pulses are regularly available. End-users are not always able to accumulate or store small individual quantities in order to aggregate them over time into parcels large enough to justify commencing use of that particular pulse in their diets. Consistent, regular pulse production and an appropriate infra-structure to store and aggregate pulses would be highly beneficial.

SOURCING PULSES

New, improved pulse varieties are now available, and have greatly increased the areas of adaptation and yields. As well they have improved the consistency of pulse production. Seasonal rainfall however continues to be the greatest single factor in influencing variations in crop production.

The major pulses used in the feed industry are lupins, field peas and faba beans. Those utilised on a smaller scale include chickpeas, mung beans, lentils, navy beans and other culinary beans. The human consumption value of these crops normally far exceeds their stockfeed value. Generally, they only appear in the stockfeed market as downgraded material, screenings or oversupplies. Other pulses that may occasionally become available as ruminant feed grains include: grain vetches; or the newer, minor crops like narbon beans, dwarf chickling, grass pea or bitter vetch.

Most are grown for their rotational value as a forage, grazing or manure crop.

Availability of pulses at competitive prices for the domestic stockfeed market is often limited by regionalised production and competitive export opportunities. For example, field peas have been exported from Victoria and South Australia despite the potential for greatly increased consumption in domestic compound feeds. However, domestic use of pulses like beans and peas has over-ridden exports at times of rising prices for stock feed due to short supply, such as that caused by drought for an extended period from 2002.

Table 4 shows utilisation of pulses 2001-02 to the 2006-07 fore-cast for the major pulses (ABARE 2006).

Tables 5 and 6 illustrate Australian pulse area sown and production from 1985/86 to 2006/07.

Table 4: Utilisation of the Major Pulses, 2001-02 onwards

	2001-02 kt	2002-03 kt	2003-04 kt	2004-05 kt	2005-06# kt	2006-07# kt
Lupins						
Production	1215	726	1180	937	1079	340
Apparent domestic use*	599	750	468	508	593	204
Exports	416	175	712	365	536	136
Field peas						
Production	512	178	487	289	478	360
Apparent domestic use*	87	85	89	96	146	148
Exports	428	96	221	115	215	227
Chickpeas						
Production	258	136	178	116	123	272
Apparent domestic use*	13	13	9	9	19	21
Exports	272	113	190	152	179	258

* apparent domestic use calculated by residual of production less export less reduction in stocks
# ABARE estimate or prediction

Source: Australian Bureau of Statistics "Australian Crop Report" No 139.

When the rotational value of pulses to increase yields in the following cereal crop is taken into account, the Australian pulse industry is now valued at almost one billion dollars, having more than doubled in the ten years since 1996.

The area sown to pulses was an estimated 1.40 million hectares in 2005/06. The area had initially increased from 0.88 million hectares in 1985/86 to stabilise at a peak between 2.02 to 2.39 million hectares sown during the 1994/95 to 2000/01 era.

The currently reduced area of pulses sown is primarily associated with reduced lupin sowings in Western Australia.

During the initial period of expansion, pulse production rose from 0.85 million tonnes in 1985/86 to peak at 3 million tonnes in 1999/00. Seasonal conditions impact on production. Lower than average yields and tonnage were produced in 2002 because of a national drought. In 2004 poor rainfall and high temperatures in spring led to unfulfilled yield potential.

The maintenance of pulse area sown is now driven by farmer recognition of the need to move to a more sustainable, whole farm approach to farming systems that includes tillage methods, stubble retention and crop rotations to manage weeds, disease, soil structure and market diversity. In some areas pulses are the most profitable crop grown, in others they compliment the cereals in rotation.

The growth in pulse area sown in the 1980's to mid 1990's was originally driven by poor returns from traditional cereal crops. There had also been a need for alternative crops which competed in primarily unsubsidised export markets outside of European Economic Perspectives (EEP) and the European Union's Common Agricultural Policy (CAP). The era also saw the emergence of the new pulse crops lentils and faba beans.

Table 5: Area Planted (ha x 1000), Australia, 1985/86 to 2006/07

Year	Lupins	Field peas	Chick peas	Lentils	Faba beans	Mung beans	Navy beans	Vetch	Total
					'000 hectares				
85/86	588	217	26	na	19	33	7	na	**877**
86/87	747	314	68	na	38	44	11	na	**1209**
87/88	1015	444	55	na	51	25	11	na	**1590**
88/89	850	456	68	na	50	40	8	na	**1464**
89/90	801	326	93	na	45	21	5	na	**1286**
90/91	793	318	178	0	44	31	9	13	**1376**
91/92	939	427	250	0	58	34	4	21	**1729**
92/93	1032	382	152	0	82	32	6	93	**1774**
93/94	1150	400	147	1	87	21	10	36	**1841**
94/95	1407	461	209	6	86	29	7	23	**2215**
95/96	1323	382	216	8	80	35	5	34	**2070**
96/97	1259	336	241	18	97	51	6	40	**2024**
97/98	1424	367	273	57	155	46	7	40	**2304**
98/99	1407	370	309	66	135	102	na	65	**2388**
99/00	1347	423	218	75	147	48	na	62	**2245**
00/01	1180	397	262	117	206	88	na	37	**2170**
01/02	1139	337	195	158	180	43	na	34	**1928**
02/03	1025	380	201	165	157	44	5	63	**1869**
03/04	851	354	152	131	155	44	6	14	**1569**
04/05	839	321	113	119	195	50	na	30	**1547**
05/06	757	285	103	117	180	44	na	31	**1400**
06/07*	500	342	260	153	168	na	na	na	na

*Source: ABARE, * Pulse Australia*

The major production areas in Victoria are the Wimmera and southern Mallee. Field peas are the dominant crop, as they are in South Australia, with the Lower to Mid North and Yorke Peninsula the major production areas. There has been a move of peas to drier, harsher areas where crops like lentils or faba beans cannot be grown as reliably. Southern New South Wales is the largest production area for field peas and lupins in that state, with chickpeas concentrated in the north. Outside of Western Australia, lupins are predominantly grown on Eyre Peninsula and in the south-east of South Australia.

GEOGRAPHIC LOCATION

Due to variations in climatic conditions, there is significant regionalisation of pulse production. In southern Australia, lupins, field peas, faba beans and chickpeas are grown. In the north east grain belt, chickpeas are the dominant crop, with beans and peas increasing. The north also has a significant summer pulse industry including mung beans, peanuts, navy beans, cow peas and pigeon peas.

Regional areas of production and location of the demand in the feed industry are important. Table 7 shows the historic contribution to production by State. Table 8 shows ABARE projections of grain supply 2007/08 modelled across the regional 'supply' regions.

Table 6: Australian Pulse Production by Year (t x 1000), 1985/86 to 2005/06

Year	Lupins	Field peas	Chick peas	Faba beans	Lentils	Mung beans	Navy beans	Vetch	Total
					'000 tonnes				
85/86	524	241	36	29	na	13	5	na	**848**
86/87	802	513	63	69	na	15	8	na	**1462**
87/88	855	487	54	73	na	12	9	na	**1481**
88/89	927	517	86	63	na	22	4	na	**1615**
89/90	772	388	109	58	na	8	3	na	**1336**
90/91	758	318	192	53	0	16	9	14	**1350**
91/92	1047	473	222	64	0	20	4	26	**1852**
92/93	1195	456	177	99	1	15	4	95	**2037**
93/94	1480	558	193	135	1	27	5	40	**2433**
94/95	1076	240	69	50	2	13	6	12	**1460**
95/96	1559	530	287	128	16	17	4	34	**2554**
96/97	1523	454	288	171	38	34	5	40	**2509**
97/98	1561	316	199	163	36	23	3	33	**2294**
98/99	1696	370	188	194	39	78	7	22	**2548**
99/00	1968	496	230	226	103	41	6	53	**3015**
00/01	1055	456	162	325	163	52	7	28	**2078**
01/02	1215	512	258	350	266	43	na	30	**2408**
02/03	726	178	136	108	67	34	na	49	**1230**
03/04	1180	487	178	277	175	47	na	53	**2222**
04/05	948	321	116	168	83	53	na	38	**1643**
05/06	952	372	126	302	169	48	na	40	**1840**

Source: ABARE

Table 7: Australian Pulse Production by State (t x 1000), 1987/88 to 2005/06

Production	NSW	Victoria	QLD	WA	SA	Australia
1987-88	143	310	27	759	239	**1481**
1988-89	153	335	56	833	236	**1615**
1989-90	121	298	47	637	230	**1336**
1990-91	169	218	100	642	219	**1350**
1991-92	180	390	53	901	326	**1852**
1992-93	287	541	24	852	330	**2037**
1993-94	271	573	24	1220	342	**2433**
1994-95	42	147	18	1023	230	**1460**
1995-96	191	578	25	1370	389	**2554**
1996-97	188	511	49	1352	409	**2509**
1997-98	175	257	46	1442	373	**2294**
1998-99	304	248	93	1472	428	**2548**
1999-00	409	374	69	1771	391	**3015**
2000-01	314	338	89	854	483	**2078**
2001-02	391	323	86	1008	597	**2408**
2002-03	123	37	103	615	302	**1230**
2003-04	185	246	118	1087	531	**2222**
2004-05	269	109	52	928	285	**1643**
2005-06	272	175	74	931	389	**1840**

Source: ABARE

Western Australia usually accounts for just under 50% of Australia's pulse production. The main product grown being narrow-leafed lupins which account for about 84% of total Australian lupin production. Small quantities of field peas and chickpeas are also grown.

South Australia accounts for approximately 17% of pulse production and is the largest producer of faba beans. South Australia is also a major producer of field peas with other crops including lupins, broad and faba beans, lentils and some chickpeas and vetch. South Australia is highly export oriented, with over 50% of its total production being exported annually (beans, lentils especially, but also peas in the past). Since 2002, South Australia has supplied a considerable quantity of lupins and peas to the eastern states domestic feed market.

Victoria produces approximately 25% of total pulse production and 60% of field peas. The state produces a range of pulses including lentils, field peas, lupins, faba beans and a few narbon beans and vetch. Chickpeas are about to be extensively grown again with new varieties available to overcome the disease ascochyta blight which devastated the southern chickpea industry from the late 1990's until now.

Southern and Central New South Wales production is dominated by lupins and field peas, although now faba beans also play a significant role. The trend has been for increased interest in lupin production and in particular albus lupins because of its export potential as a food crop. Late seasonal starts severely impact on actual lupin sowings. The major crop in Northern New south Wales is chickpeas with mung beans, faba beans and now field peas increasing in area. Faba bean area has rapidly increased with the release of adapted varieties from 2004.

Queensland accounts for almost all of the navy bean crop, 80% of the Australian mung bean crop and approximately 20% of the chickpea crop. It is also the dominant supplier of peanuts.

Queensland is a major supplier of chickpeas. However, adverse seasonal conditions in the early 1990's and expansion of the crop in southern and western states saw its share of this market fall as the total crop size increased. Since the southern demise of chickpeas due to ascochyta blight in the late 1990's, Queensland and northern New South Wales again became the major suppliers of chickpeas in the early to mid 2000's. Adzuki beans, cow peas, faba beans, lab lab, pigeon peas and lentils all have potential in niche areas in Queensland.

Table: 8 Projected Grain Supply by Region (kt) 2007-08 (ABARE*)

Supply region	Lupins	Peas	Faba beans	Pulses total	Cereals	Protein meals	Other	TOTAL
Qld coastal central	0	0	1	**1**	**652**	**40**	**59**	**752**
Qld south west	0	0	1	**1**	**725**	**111**	**20**	**857**
NSW north	1	1	1	**3**	**1058**	**589**	**164**	**1815**
NSW central west	14	6	9	**29**	**1425**	**101**	**0**	**1554**
NSW south	5	0	1	**6**	**128**	**14**	**82**	**230**
NSW lower west	31	21	30	**82**	**1629**	**22**	**48**	**1780**
Vic north east	11	10	6	**27**	**409**	**120**	**111**	**666**
Vic north west	18	117	68	**203**	**1666**	**0**	**0**	**1869**
Vic-SW & SA lower SE	6	2	1	**9**	**301**	**0**	**76**	**386**
SA east	37	40	23	**100**	**811**	**22**	**44**	**976**
SA west	36	167	95	**298**	**2474**	**0**	**0**	**2772**
WA south	164	14	5	**183**	**1859**	**16**	**32**	**2090**
WA north	1078	35	12	**1125**	**4439**	**0**	**0**	**5564**
TOTAL	1402	412	251	**2065**	**17575**	**1035**	**636**	**21311**

** from Australian Grains Industry 2003 (Connell and Hafi 2003)*

STORAGE AND HANDLING OF PULSES

Storage on farm or in ware-house facilities is becoming more common as growers realise the benefits of marketing their pulses after harvest compared with sale "off the header". Storage on farm also allows segregation, traceability, product identification and quality assurance options. Grain must be dry and cool (preferably <20°C, but definitely <27 °C) for safe storage.

Insect pests of stored pulse grains are minor compared with cereals. The main concern is to avoid storage moulds and "bin burnt" appearance by ensuring that pulses are stored without excessive moisture content.

Generally, pulses are easy to store, provided excessive moisture content is avoided. Storage pest management will be minimal if cleaned of cereal and weed grains and residues prior to storage. Chemical pest control may not be required if storage is short term.

End-user preference is for chemical residue-free grain. Sealed silos enable fumigation use in insect control measures. Aerated storage enables cooling of grain, reduction of moisture content and maintenance of grain quality. Grain bags or 'sausages' are becoming popular as short term storage in the paddock at harvest. These must be viewed as temporary storage measures.

Pulse grains may darken quicker with age in these bags. Vermin and other pests can damage the grain bags plastic sides, causing spillage and loss of quality.

Most pulses require "soft handling" to minimise damage in conveying equipment. Splitting, cracking or dehulling, with a reduction in viability, can occur in peas, faba beans and chickpeas when conveyed with screw augers. Belt conveyers are recommended to avoid this damage.

Lupins suffer less from visibly physical damage due to their tougher seed coat, but the damage is internal, causing a loss of viability if handled too often. Lupins are unsuitable for use on roller mills. Storing lupins prior to use can reduce the moisture content and improve their milling ability. Lupins can also be difficult to mix without proper equipment.

Broad beans may pose slightly greater handling difficulties because of their large size.

ON FARM USES OF PULSES

Many mixed farms are increasingly able to utilise pulse crops as an integral part of a whole farm livestock and cropping program. Grazing of pulse crop residues can be financially beneficial, but is not always desired by farmers wishing to preserve soil structure and ground cover. Feeding of pulse grain retained on farm can compliment the livestock enterprise, either in simple feedlots or as a grazing supplement aimed at finishing stock for slaughter or in preparation for mating.

Broadcast feeding pulse grain on cereal stubble can assist in stubble breakdown and utilization. Feeding pulse grain on pasture land can extend the finishing process or condition lambs prior to entering the feedlot or pulse stubble grazing. Larger seeded pulses like broad beans are easy to feed out to sheep and cattle with minimal wastage.

Farm simulation models like MIDAS (Model of an Integrated Dryland Agricultural System) and MUDAS (Model of an Uncertain Dryland Agricultural System) developed by the Department of Agriculture Western Australia can assist growers in deciding financially and agronomically what percentage of their farm should be sown to a pulse and how it compliments their grazing and cropping enterprises.
See **www.agric.wa.gov.au/servlet**

GRAZING PULSE STUBBLES

When grazing pulse stubbles to finish lambs, there are some key points to maximise animal performance (McNeil 2004). Lambs should have been introduced to the pulse grain beforehand. Ideally this should occur when the lamb is still with the ewe (imprint feeding). They must have the required base weight (45kg) to start grazing the stubble. The lambs must have very good access to water. One trough per 300 lambs is suggested, hence temporary troughs may be needed. Determine the stocking rate by assessing the pulse grain on the ground (harvest losses). Graze the stubble in two or three grazing cycles to finish the total number of lambs required, rather than graze all the lambs at one time. Observe any export slaughter interval that may exist for particular pesticides used on the pulse crop.

When grazing lupin stubble, the risk of lupinosis must be managed. For full details, see Croker *et al (1994, 2005).* Important agronomic issues are the cultivar used and the intensity of lupins in the paddock rotation. Grazing management to mitigate the risk of lupinosis becomes critical. Early grazing is an important part of this to ensure that stubbles are not grazed after autumn rains. Remove the stock when residual grain is eaten out. Sheep tend to gain weight only when there is more than 50 kg of lupin seed per hectare in the stubble. Monitor the stock closely and remove them from lupin stubbles at the first sign of lupinosis symptoms. Weaner lambs are most vulnerable to lupinosis, partly because if they are not accustomed to lupin seeds they are more likely to eat pods and stems. The presence of green feed, including lupin seedlings, does not mean that grazing lupin stubbles is safe.

Move the stock a few hundred metres and take a close look at any stragglers for symptoms like jaundice. Early symptoms of lupinosis include hollow flanks, lethargy when driven, visibly poor growth rate and stragglers not keeping up with the mob or staying near water points. More pronounced symptoms are disorientation, blindness, and hunched appearance, reluctance to move and jaundice (yellowing) of the membranes around the eyes and in the mouth.

ACCESS LIMITATIONS AND QUARANTINES

Generally access to pulses for livestock feed is unrestricted, but there are exceptions. Access is limited mainly by commodity price, storage, transport costs if from a distant source, product quality issues concerning weed seeds and other contaminants, or occasional plant quarantine regulations.

Movement of lupins from Western Australia and South Australia is restricted into Victoria and New South Wales because of the plant disease, anthracnose. Permission from the importing State Government Agriculture Department is required for each consignment. Whole lupin grain entering New South Wales or Victoria must be tested free of anthracnose, and therefore incurs an additional cost compared with grain grown within that state.

Strict transport, processing and destination protocols exist for lupins with unknown or positive anthracnose status. Infected or suspected grain can only be sourced if denatured or ground first, or if it is going into a processed feed.

Lupin importation from the eastern states into Western Australia has been prohibited since 2005 until the risk of the lupin disease *Phoma schneiderae* detected in Victoria is known.

Check state government web sites for specific quarantine information and marketing protocols, as importation restrictions can change from year to year.

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