Tracking potential GM inputs to the stockfeed supply chain for feedlot beef: a discussion paper

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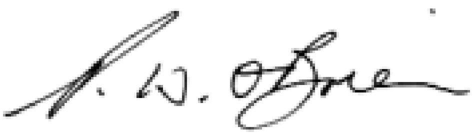
Foreword

Australian livestock industries use a wide range of stockfeed ingredients that are, or may in future be, derived from genetically modified (GM) organisms. Some meat and livestock markets may in future require certification that the product does not contain GM stockfeed inputs. Producers wishing to access these particular markets may need to verify claims assuring their customers that all ingredients and processes used throughout the supply chain do not contain unapproved GM material.

Cotton is the only GM crop produced in commercial quantities in Australia and used for stockfeed. However soy and maize products, imported from the United States where all GM crops are comingled with conventional crops, are also used in stockfeed. This study responds to a need to inform policy development and public debate on the issue of GM inputs to the supply chain for stockfeed in Australia. It reviews some of the major crop products that enter the stockfeed supply chain for feedlot beef and identifies those that are currently produced from GM varieties or are likely to have GM varieties in production in the future.



Dr Peter O'Brien
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Executive summary

Australian livestock industries utilise a wide range of stockfeed components that are, or may in future be, derived from genetically modified (GM) organisms. To guide discussion of this issue, we have reviewed the stockfeed supply chain of one livestock industry (feedlot beef) and one set of stockfeed ingredients (products derived from some major crops).

The issue of GM crops in stockfeed is discussed with reference to feedlot beef production and ...

The stockfeed supply chains of six representative crops are described in detail: field peas, lupins, cotton, canola, maize and soybeans. These crops are used to produce a wide range of stockfeed products including grain, hay, silage, and seed meals. They were selected for this study because there are GM varieties in advanced stages of development, or already marketed in some countries. There are currently no GM feed crops commercially grown in Australia with the exception of cotton, a co-product of which is used to supplement some feeds. The only other GM inputs to stockfeed from major crops are imported soybeans and imported maize at this stage.

... six representative crops: field peas, lupins, cotton, canola, maize and soybeans.

The feedlot beef stockfeed supply chain is a diverse set of supply networks that constantly change as lot feeders alter the composition of their rations to optimise nutrition and minimise cost. A single crop can be the source of several stockfeed ingredients including grains, seed meal, hay and silage. A single stockfeed ingredient can enter the ration through one of several pathways including directly from a domestic producer, via imports, through manufacturers of stockfeed or human food and via agents and marketers.

The 'supply chain' for stockfeed ingredients can be described as a diverse set of supply networks which change constantly.

To demonstrate the GM status of crop inputs to animal industries would require a supply chain systems approach for each stockfeed ingredient.

The potential market demand for feedlot beef raised solely on non-GM feed remains uncertain. A supply chain management approach would be required to demonstrate that animals have not consumed stockfeed containing GM products, because end point testing of animal products is not able to determine the GM status of feeds consumed. Given the wide range of supply chain arrangements potentially used by any one feedlot, it would currently be difficult for producers to assure customers that their feed did not contain GM material if their rations contained cottonseed, imported soybeans or imported maize. This situation is analogous for livestock producers in Europe where imported soy and maize are used in stockfeed. In North America, there is little or no segregation of GM and non-GM soybeans, maize, cotton and canola used in stockfeed.

Contents

1. Introduction

1.1 Background

No legislative requirement currently exists in Australia or export markets to label meat from animals fed GM material. However, some markets may in future require certification that the product does not contain GM stockfeed inputs. Producers wishing to access these particular markets and meet their requirements, may need to verify claims assuring their customers that all ingredients and processes used throughout the supply chain do not contain GM unapproved material.

In 2001, BRS undertook a literature review study for Meat and Livestock Australia which examined issues arising from the use of genetically modified (GM) crops and pastures as feed for animals destined for human consumption. It noted a concern that recombinant DNA will enter animal products such as meat and in some way may be passed on to humans. The review considered that one way of managing the issue was by product segregation through animal identification and identity preservation.

1.2 Terms of reference

In March 2003, the Rural Policy and Innovation Business Unit (RPI) of the Department of Agriculture, Fisheries and Forestry commissioned the Bureau of Rural Sciences (BRS) to write a discussion paper on GM inputs to the supply chain for feedlot cattle stockfeed. The objectives were to:

- Schematically map the supply chains of stockfeed produced for feedlot beef; and
- Identify and quantify current and potential GM inputs to the stockfeed supply chain for feedlot beef.

This report maps the supply chain of stockfeed produced for feedlot beef from paddock to stockfeed to the feedlot (Figure 1). Points in the supply chain where GM products may enter are identified with a focus on the macro-ingredients, specifically the crops field peas, lupins, cotton, canola, maize and soybeans and products derived from these crops used in stockfeeds. It does not cover GM feed supplements, vaccines or food safety issues, although these issues will need to be considered by industries wishing to declare themselves free of GM inputs. This study quantified the current volumes of major crop products in stockfeed including imported and domestic products, focusing on the macro-ingredients identified above. Current markets for lot-fed beef are also identified and quantified.

Australian livestock industries utilise a wide range of stockfeed components that are, or may in future be, derived from genetically modified organisms. To guide discussion of this issue, we have reviewed one livestock industry (feedlot beef) and one set of stockfeed components (products derived from major crops). Similar issues would be relevant for the dairy, pork and poultry industries. The stockfeed supply chains of the six representative crops are described in detail. These crops are used to produce a wide range of stockfeed products including grain, hay, silage, and seed meals. They were selected for this study because there are GM varieties in advanced stages of development, or already on the market. The GM traits that are currently commercially available are designed to improve the management of the host crops and are not specifically aimed at improving the crop for livestock feed. These crops are grown directly for feed, their by-products are used for feed or are imported for feed. Other major crops that were not included in this study but may be used for stockfeed are wheat, barley, sorghum and oats. Foster (2001) states that GM wheat may receive regulatory approval for commercial release in 2003 in the US, however Gunderson (2003) reports that concerns about export market access for the wheat are likely to delay this. Although feedlot cattle are raised on pastures, which may in future include GM varieties, the scope of the project is limited to the stockfeeds used in the cattle feedlot (Figure 1). A related study commissioned by AFFA is analysing quality management systems relevant to GM pastures for the dairy industry (Lovell *et al.* in prep.).

In this discussion paper, we identify areas in each representative supply chain where GM or potential GM products may form part of a ration for feedlot beef. In most cases, we quantify the current and potential inputs of these products to the feedlot beef stockfeed supply chain (at a national level).

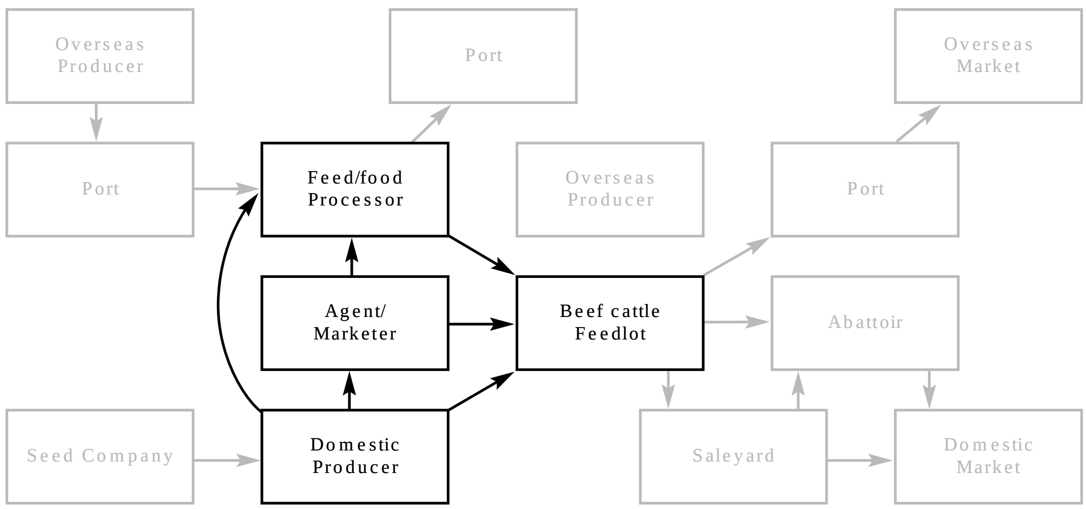

Figure 1. Scope of this discussion paper on potential GM feed inputs (black text indicates subjects within the scope, grey text indicates areas outside the scope).

2. The beef cattle feedlot stockfeed supply chain

2.1. Introduction

A cattle feedlot is "a confined yard area with watering and feeding facilities where cattle are completely hand or mechanically fed for the purpose of production" (SCARM 1997). While pastures constitute the major source of beef feeding in Australia, the practice of finishing cattle in feedlots is increasing. In 2001, approximately 26% of Australian beef was finished in feedlots and this proportion is predicted to increase in response to market demands for higher and more consistent beef quality (Dee 1994; AHA 2000; Tilley 2001; MLA 2003).

The growth of export markets for beef that required a consistent supply of cattle uninterrupted by climatic conditions led to the rapid expansion of the Australian lot feeding industry in the mid 1980s (ALFA 2002). In 2001, the major destinations for lotfed cattle were the Japanese (56.9%), domestic (36.2%) and Korean (4.4%) markets (Tilley 2001). In 2001 less than 1% of all beef exports were shipped to the European Union (MLA 2003a).

In Australia, there are approximately 680 accredited feedlots for cattle with a total carrying capacity of 920,000 head. On 30 June 2000 there were around 673 000 cattle in feedlots. The majority of these feedlots are located in south east Queensland and New South Wales (MLA 2003; AHA 2000).

The demand for feedlot beef in the domestic market is generally for steak with 3 to 5 mm of fat cover requiring a lightly finished animal. Japanese markets require heavier animals with a greater quantity of subcutaneous (beneath the hide) and intramuscular (marbling) fat. The type of meat required influences the length of time an animal will spend in the feedlot and their rations. Producing lighter animals requires a higher protein ration while producing fatter animals requires a higher energy diet (Bertram 1998).

2.2. Components of the beef cattle feedlot ration

Over 10 million tonnes of stockfeed are used each year in Australia with the beef feedlot industry accounting for around 2.2 million tonnes. Other major users of stockfeed are the dairy, pork and poultry industries (SFMAA 2003). Lot feeders use the term ration to describe the combination of feed products supplied to the cattle in the feedlot. They use rations which optimise feed conversion efficiency and weight gain whilst minimising cost and digestive problems (Sneath and Wood 2000). It is possible to purchase complete commercial diets from stockfeed manufacturers, although this is rare in eastern Australia. Beef cattle lot feeders generally manufacture their own rations from a range of ingredients. Lot feeders are opportunistic when sourcing inputs and can purchase directly from producers, bulk handlers and agents (Figure 2).

The major components of beef cattle stockfeed are grains and dry roughage typically at a ratio of 75:25 or 80:20 but this varies from 50:50 to 90:10 depending on factors such as the age of the animal and weight gain goals (Dee 1994; Blackwood *et al.* 2000; Sneath and Wood 2000).

Grains may comprise up to 80% of the whole ration while roughages can form up to 40%. Other components of the ration include vegetable protein meals, molasses, vitamins, minerals, buffers, amino acids, enzymes, common salt and antibiotics (Figure 3). Appendix A lists 80 potential stockfeed ingredients derived from over 30 crops.

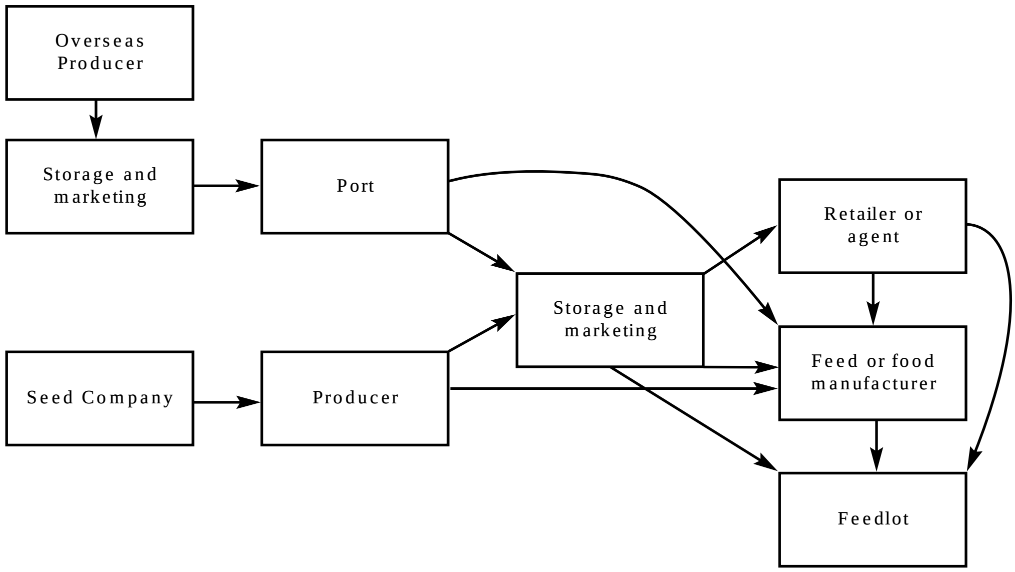

Figure 2. General supply chain for cattle feedlot stockfeed.

Grains

Grains are generally high in crude protein and metabolisable energy and deliver high liveweight gain and feed conversion efficiency, and are approximately 90% dry matter (Sneath and Wood 2000; Blackwood *et al.*2000). Whole grains that are often included in the feedlot ration are sorghum, maize, wheat and barley (Forster 2000; Sneath and Wood 2000). Maximum proportions of grains in the stockfeed ration are limited by nutritional considerations (e.g. wheat should be less than 80% of the ration) and potential risks of residue contamination (e.g. cottonseed should be less than 15% of the ration) (Blackwood *et al.* 2002)

Grains are often processed to increase both the availability of metabolisable energy and the digestibility for cattle. Processing methods can be 'dry' and include roller milling and pelleting, or 'wet' and include steam flaking, high moisture storage and reconstitution. Most large feedlots use a wet processing system whilst smaller feedlots generally use roller mills to process the grain (Forster 2000; Courtney, 2002).

A variety of grain crops can also be made into silage and hay as described below. Depending on the stage of harvest, they may provide roughage only or a combination of roughage and grain

Roughage (including hay and silage)

Roughages are high in fibre and maintain a healthy digestive system in animals. They include hay, silage, legumes and cottonseed by-products (Blackwood *et al.* 2000; Sneath and Wood 2000; Blackwood *et al.* 2002). Roughages are generally reduced to 8-12 cm pieces by hammer milling or tub grinding and are mixed with grains and other additives in open troughs (Forster 2000).

Silage is an anaerobically preserved feed resource for ruminants and is stored in a variety of ways (Regan 2000). It can be made from most pasture and fodder crops and can be baled and can include the stalks, grains and leaves (see Appendix A) (Regan 2000; Mills 2001). The plant material is forage harvested in the paddock (~30% dry matter) and then either stored in bunkers, pits, towers or in plastic film (Regan 2000; Mills 2001). Haylage is similar to silage but uses material with a higher dry matter content (~50% dry matter) (Regan 2000). Good quality hays, which are wilted on the ground to reduce moisture content (~75% dry matter) before baling can be fed at up to 30 or 40% of the total ration (Blackwood *et al.* 2002).

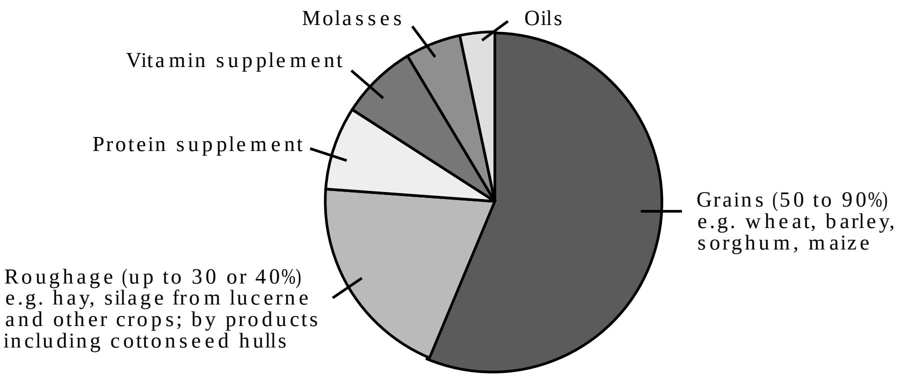

Figure 3. Major components of a stockfeed ration by category (various sources).

Other major ingredients

Vegetable protein meals boost appetite and improve growth and are sourced from various crops including cottonseed, soybean, sunflower, linseed, peanuts, copra (dried coconut kernel) and palm kernels.

Molasses is a by-product of sugar production, has a high metabolisable energy level, low crude protein and is a source of sulphur and potassium (Sneath and Wood, 2000). It also improves palatability and reduces dust problems, and can comprise up to 10% of the feedlot ration (Blackwood *et al.* 2002).

Minor ingredients

Urea is a non-protein source of nitrogen to aid digestion and comprises less than 1% of the feedlot ration. Other components of the feedlot ration are limestone to increase calcium levels; Dicalcium phosphate, Kynofos 21 and other sources to increase phosphorus levels; muriate of potash to increase potassium and general mixes to increase trace minerals and vitamins such as magnesium, chlorine, copper, iron, cobalt, selenium, iodine, zinc, manganese, vitamin A and vitamin E. Common salt is often included in the feedlot ration to meet sodium requirements. Sodium or calcium bentonite is used as a weak buffer for cattle on grain based diets. Antibiotics are added to the ration to increase feed efficiency, improve animal health, reduce bloat and promote growth (Blackwood *et al.* 2000; Sneath and Wood, 2000).

3. Field peas in stockfeed

3.1. The supply chain for field pea products in stockfeed

Field peas are useful for livestock feeds due to their high levels of protein and carbohydrates (Anderson *et al*, 2002; AWB 2003). However they do not form a large component of the feedlot ration for cattle and other ruminants because they are expensive and the protein is mostly degraded in the rumen instead of being absorbed through the intestine (Edwards 1997). Generally field peas are the preferred pulses in the pig and poultry industries (a pulse is an edible legume crop eg. peas, soybeans and peanuts) (Imrie 1998). Crude protein levels in field peas vary according to variety and environmental factors and must be tested before inclusion in feedlot rations (Anderson *et al.* 2002).

The supply chain for field peas in stockfeed is the most straightforward of the crops examined in this study. This is because they are predominantly grown for stockfeed, they are not a by-product of another industry and they are not imported.

Sowing occurs from May to early June and harvesting takes place as soon as the crop is mature using either an open front harvester with lifters or pick-up attachments (NRE 2003; TOPCROP 1998). Field peas intended for the domestic feed market are handled like most other commodities. They are stored on-farm or at local grain elevators in sheds, bunkers and silos (Anderson *et al.* 2002) (Figure 4).

Stockfeed manufacturers and feedlot operators purchase field peas directly from domestic producers and grain handlers except in Western Australia where the Grain Pool of WA handles their distribution (Imrie 1998). No processing occurs before they go to stockfeed.

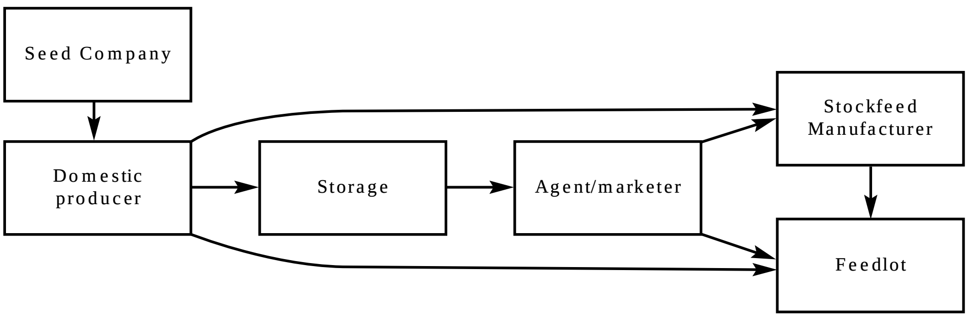

Figure 4. The supply chain for field peas in stockfeed.

3.2. Current and potential GM field pea inputs to the feedlot beef stockfeed supply chain

Transgenic field peas are not currently grown commercially anywhere in the world, so GM varieties will not be present in current stockfeeds (AgWest 2002). There have been field trials of six varieties with GM traits in Australia (OGTR 2003).

Field peas are the second largest pulse crop in Australia with the majority of production occurring in Victoria and South Australia (Imrie 1998). Around 40% of Australia's production of field peas is used domestically as stockfeed (Figure 5) (Lucy 2002). A large amount of the field peas produced are exported.

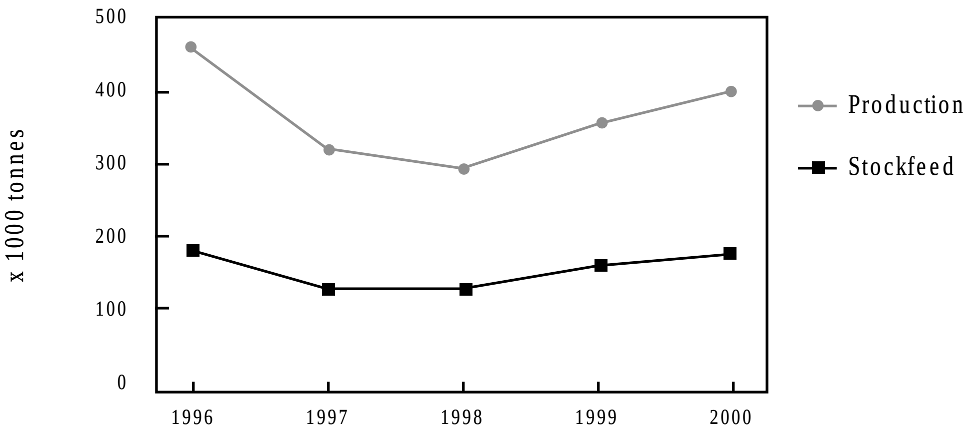

Figure 5. Australian production of field peas and estimated domestic use as stockfeed (Data source: GRDC 2001, estimated stockfeed use based on 40% of domestic production according to Lucy 2002).

There are no inputs of transgenic field peas to the stockfeed supply chain at present. CSIRO scientists are currently undertaking research into high protein varieties of GM field peas, however these will not be released for commercial production in the near future (TJ Higgins, CSIRO, personal communication 2003). This will most likely be important for the pig and poultry industries, as only a limited quantity of field peas will enter the feedlot beef supply chain.

4. Lupins in stockfeed

4.1. The supply chain for lupin products in stockfeed

Lupins are high in protein and can be utilised in a wide range of stockfeed (Lucy 2002a). Protein and carbohydrate levels are higher in lupins than soybeans and oil content is lower (Anderson 2000). The protein content can be increased by up to 13% by removing the seed coat (AWB 2003a; Lucy 2002a). Whilst field peas are generally used as feed in the pig and poultry industries, lupins are preferred in ruminant diets because of lower prices (Imrie 1998).

The supply chain arrangements for lupins are similar to those for field peas (Figure 6). Lupin seeds are obtained either through a seed supplier or retained by the producer from previous crops (Hawthorne *et al.* 2001). Lupins are winter annuals sown around May and harvested using a conventional grain header when mature (Hawthorne *et al.* 2001; Lucy 2002a).

When lupins are included in the stockfeed ration, the seed coat may be removed mechanically and recombined with the kernel to produce meals of varying fibre content (Anderson 2000).

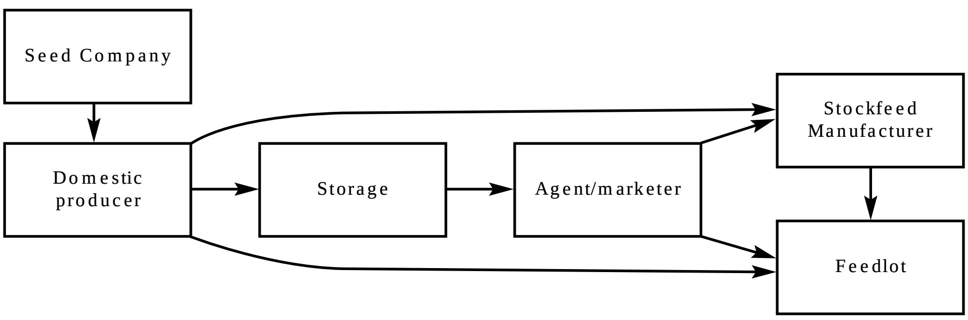

Figure 6. The supply chain for lupins in stockfeed.

4.2. Current and potential GM lupin inputs to the feedlot beef stockfeed supply chain

There are currently no commercial plantings of GM lupins in Australia although there have been field trials of three GM varieties (OGTR 2003). Australia produces 82% of the world's lupins. The other major lupin producing countries in the world are Poland, European Union, Chile and South Africa although no GM varieties have been approved for commercial release (AgWest 2002). Since Australia dominates world lupin production it is unlikely that lupins will be imported in the future.

Lupins are the largest pulse crop produced in Australia with the dominant producer being Western Australia (Imrie 1998). Approximately 1 million tonnes of lupins but up to 2 million tonnes (Figure 7) are produced in Australia each year with 99% of this being used for stockfeed (both domestic and export) and 1% for human consumption (GRDC 2001; Lucy 2002a). Over 50% of the lupin crop is exported (Anderson 2000). Approximately 200,000 tonnes of lupins are fed to cattle in Australia, predominantly in Western Australia (White 1999).

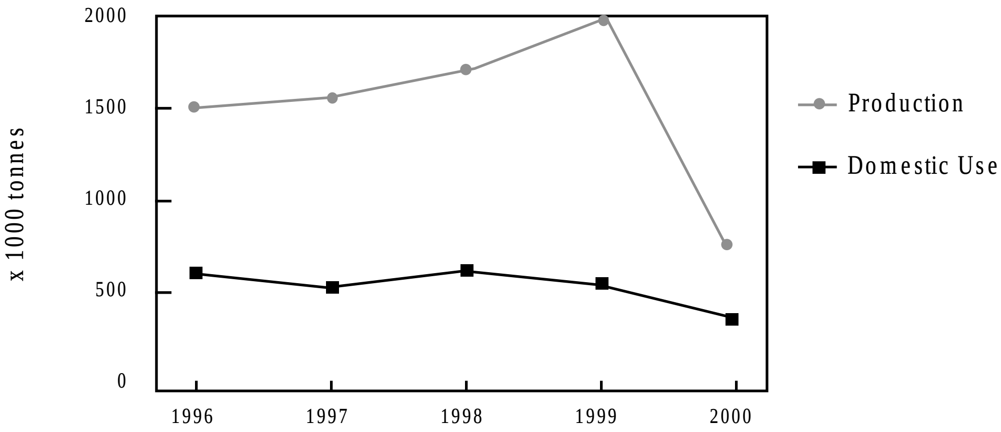

Figure 7. Australian production and domestic use of lupins (Data source: GRDC 2001, note that 99% of both domestic and export use is thought to be for stockfeed, Lucy 2002a).

Although field trials of transgenic lupins have occurred in Australia, there is no commercial production. CSIRO scientists do not expect high methionine lupins to be in commercial production before 2007 (TJ Higgins, CSIRO, personal communication 2003). As lupins are utilised for ruminant feeds in Australia, future domestic production of transgenic varieties will probably result in inputs to the stockfeed supply chain.

5. Cotton products in stockfeed

5.1. The supply chain for cotton products in stockfeed

Cotton is currently the only GM crop grown in Australia that is included in stockfeed (Thomas and O'Dea 2001). By-products of the cotton fibre industry are whole cottonseed, protein meal, hulls (tough outer covering of the seed), and trash (stem and leaves), all of which can form a component of the stockfeed ration (DPI 2003). Because of the risk of chemical residues the use of cotton trash is not recommended and the maximum recommended level of whole cottonseed is limited to 15% of the ration (Blackwood *et al.* 2002).

The majority of Australian cotton is grown in New South Wales and Queensland (AFFA 2003; DPI 2003). Cotton is usually planted in Spring and harvested in late March using mechanical spindle pickers or stripper harvesters that can be owner operated or contracted (DPI 2003; QFF 2003). These harvesters collect cotton bolls (each boll contains around 30 seeds) in on-board bins for transfer to a field module builder. This is a bin where the cotton is compacted to form a module approximately 10m x 2m x 2m in size. The module is then transported by road to a gin where it is separated (ginned) into cotton lint and cottonseed (Figure 8) (AFFA 2003).

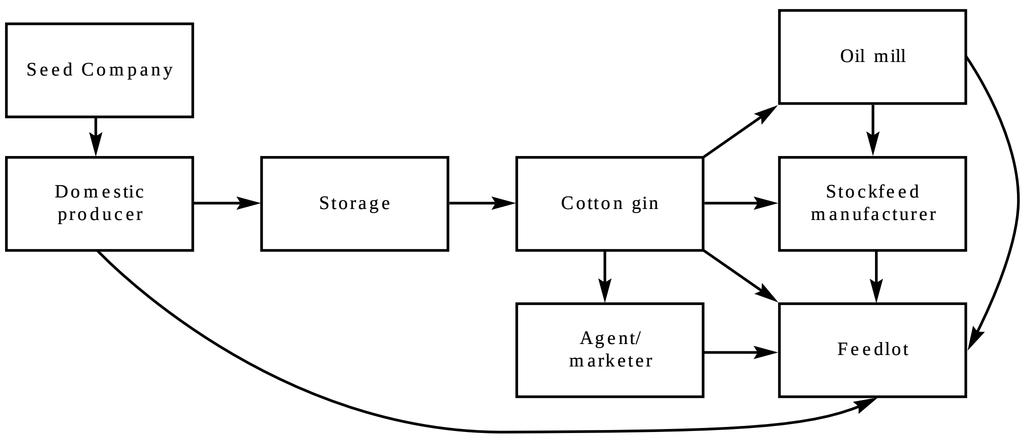

Figure 8. The supply chain for cotton products in stockfeed.

The seed remaining after the ginning process has some lint on it and is known as white cottonseed. In Australia, Cargill markets the majority of white cottonseed for the cotton ginning companies (Blackwood 2002). White cottonseed has a high fibre, energy and protein content and can be used as part of the stockfeed ration to increase dry matter intake or as a component of a drought diet in conjunction with molasses or grain (Blackwood 2002). Cottonseed is a palatable high-energy feed with high protein levels and it can comprise up to 15% of the stockfeed ration without being processed (MLA 2000; Blackwood 2002; DPI 2003).

Hulls are generally low in nutrients but provide a good source of roughage (DPI 2003). Cotton trash (leaves and sticks) may also be used as a roughage in stockfeed but there is a risk of high chemical residues and its use is discouraged (Blackwood *et al.* 2002; DPI 2003).

Most cottonseed is transported to and processed at an oil mill rather than being used directly in stockfeed. The oil extraction process involves removing the short fibres remaining on the seed and cracking the seeds to separate them into kernels and hulls (ABS 2003). The hulls are then used for stockfeed and fertiliser while the kernels are crushed to extract oil. The residue remaining after oil extraction is ground into meal and used as a protein roughage for stockfeed (ABS 2003, CA 2003).

The supply chain for cotton products entering stockfeed involves a more complex network than that for lupins and field peas, as they are by-products of an industry that is not food or feed related. Supply chain arrangements in this industry do not currently require segregation of GM and non-GM varieties. Since little or no segregation of GM and non-GM cotton currently occurs this may become an issue for the stockfeed industry if markets require certification in the future.

5.2. Current and potential GM cotton inputs to the feedlot beef stockfeed supply chain

Australia used 146,000 tonnes of cottonseed meal in 2001 (Figure 9) (Foster 2001). Approximately 40% of the New South Wales and Queensland cotton crop is grown from genetically modified seed. Therefore, cotton stockfeed products may include a similar level of genetically modified material (Blackwood 2002). In practice, the level could range from zero to 100% in any one batch of material. This material already enters the supply chain for stockfeed due to the lack of segregation in the industry. Cottonseed oil is used in food applications around the world. CSIRO is about to test GM high oleic acid varieties that will allow direct use in frying and margarine. However, the oil does not contain genetic material or protein.

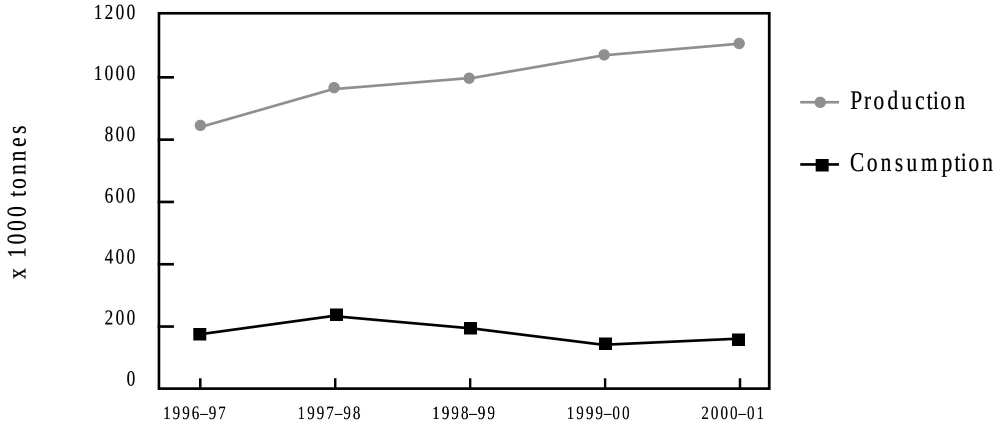

Figure 9. Australian production of cottonseed and consumption of cottonseed meal (Data source: Foster 2001).

6. Canola products in stockfeed

6.1. The supply chain for canola products in stockfeed

Canola meal is used in the stockfeed industry because it is a source of protein and has a high energy content (Brennan *et al.* 1999). Its use in stockfeed is increasing with the majority being used in south-eastern Australia particularly in Victoria (Leading Dog 2001). Canola meal utilised in the stockfeed industry is different from the three industries discussed previously in this discussion paper, as it is a by-product of a food source for human consumption.

Two companies (Monsanto and Bayer Cropscience) have made applications to the Gene Technology Regulator for the commercial release of GM canola in 2003. The Regulator released a draft risk assessment and risk management plan regarding the Bayer Cropscience application for public consultation. The Office of the Gene Technology Regulator (OGTR) is still awaiting further details before finalising its assessment of the Monsanto application.

Varieties of GM canola developed in the future may provide a source of high quality protein to be included as a stockfeed supplement. Anti-nutritional factors in canola may be reduced to improve the use of canola in stockfeed (Thomas and O'Dea 2001).

Canola is predominantly grown in winter in Australia although some small areas grow canola in late spring to early summer (OGTR 2002). Canola meal used in stockfeed is a by-product of oil production and processing (Brennan *et al.* 1999) (Figure 10). Following crushing, the meal that is produced has an oil content of around 8% (AgWest 2003).

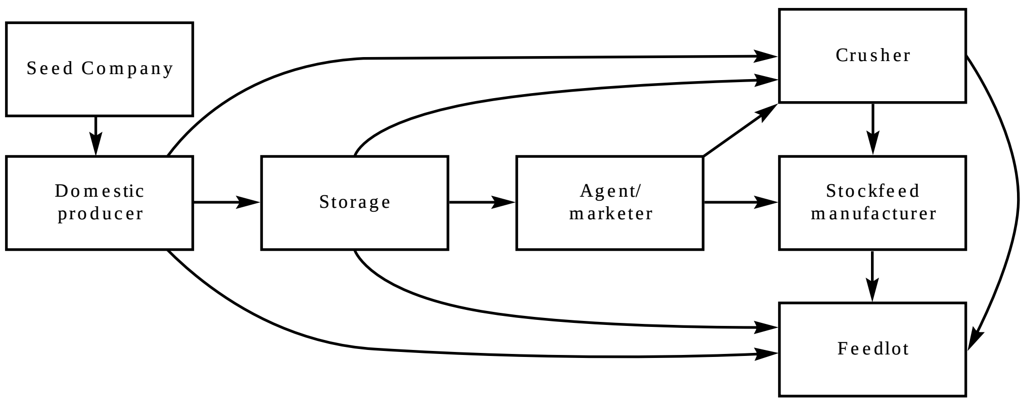

Figure 10. The supply chain for canola products in stockfeed.

6.2. Current and potential GM canola inputs to the feedlot beef stockfeed supply chain

Canola is the third largest field crop grown in Australia with around 2.4 million tonnes being produced in Australia in 1999/2000 (Foster 2001; AWB 2003b) (Figure 11). One quarter of Australian canola production is used domestically for crushing to produce oil and meal, with the meal being used as stockfeed (Leading Dog 2001).

Brennan *et al.* (1999) produced a model to predict the amount of canola meal that would be used by various livestock industries over a range of prices. They estimated that at a price of $220 per tonne, no canola meal would be used for feedlot cattle in Australia while at $100 per tonne around 250,000 tonnes would be used. The price for canola meal during the current drought is around US$122 per tonne or around AUS$212 (Market Research Inc 2003).

The planting of GM canola varieties could increase yields, allow new canola growing regions and lower production costs. These factors could potentially push the price of canola meal downwards and increase the amount of canola meal used in stockfeed.

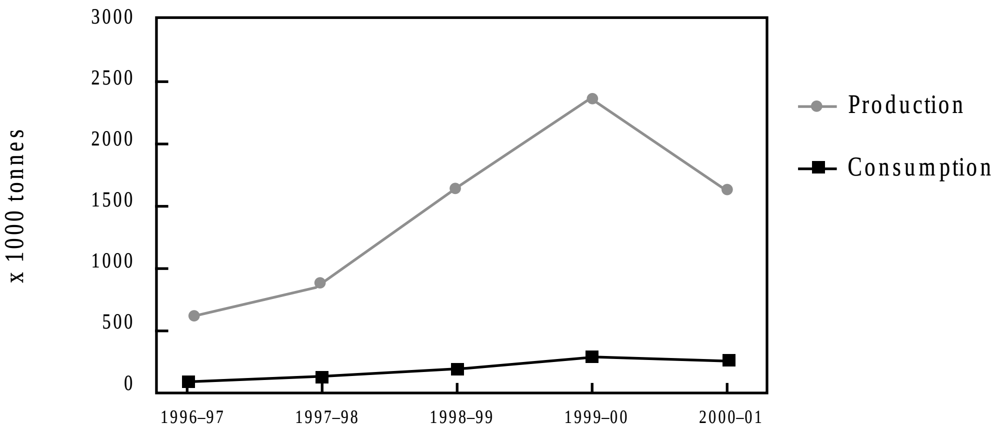

Figure 11. Australian production of canola and consumption of canola meal (Data source: Foster 2001).

Where GM varieties of canola are available to producers, up to 70% of canola grown is GM, e.g. in Canada (AgWest 2003). The only other country currently growing commercial quantities of GM canola is the USA (Foster 2003). The OGTR is currently assessing two applications for commercial release of GM canola in Australia during 2003. Without segregation of GM and non-GM varieties, it is likely that GM material will enter stockfeed when it is grown commercially in Australia.

7. Maize products in stockfeed

7.1. The supply chain for maize products in stockfeed

Maize (commonly called corn) is an excellent feed grain as it has a high metabolisable energy level but it has low crude protein content and is often more expensive than other grains. Its efficiency can be increased by rolling and 'wet' processing (Sneath and Wood 2000).

Maize can also be stored as silage and haylage. The metabolisable energy level in maize is optimised by ensuring the crop has a high grain yield at cutting with up to 50% of total dry matter

When maize silage is used as a high energy feed its digestibility can be increased by altering the cutting height of the plant thereby reducing the quantity of stalk or stover (stems and leaves) in the silage or by cracking, crushing or fine chopping the grain (Morris 2001).

Maize is sown from late August to early November depending on the location (Roe 2003; ONTAS 2003). Its active growth occurs in spring, summer and autumn. Harvesting is conducted using a machine fitted with a specialised maize harvester front or an open front header (Price 1997; Roe 2003). The crop is generally fed to stock as green chop or ensiled (ONTAS 2003).

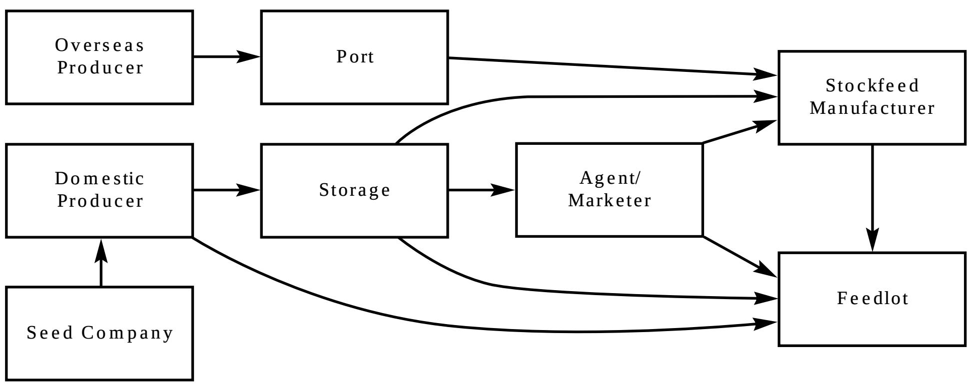

Figure 12. The supply chain for maize products in stockfeed.

Maize may also enter the stockfeed supply chain through imports especially during severe droughts (Figure 12). As the import of grain for stockfeed does not involve an intentional release to the environment, when an import licence is granted by the OGTR, the potential risks are managed using Australian Quarantine and Inspection Service (AQIS) import permit requirements. When the shipment arrives it is placed into interim storage and then transported in covered trucks to an approved processing plant in a metropolitan area. Processing includes hammer milling and steam pelletising and results in the grain being no longer viable. The pelletised feed is then distributed to feedlots (M Robbins, AQIS, personal communication, 2003). Spillage of grain must be cleaned up and the spilt grain must be destroyed (OGTR 2003a).

7.2. Current and potential GM maize inputs to the feedlot beef stockfeed supply chain

Maize is a minor cereal crop in Australia with production of around 325,000 tonnes per year (GRDC 2000; ABARE 2002). About 75% of total production crop is used in the domestic market with around 60% of this being used for stockfeed (Figure 13) (McMaster *et al.* 2000). The demand for maize as a feed grain is increasing due to the expansion of the feedlot beef industry (Robertson 2003).

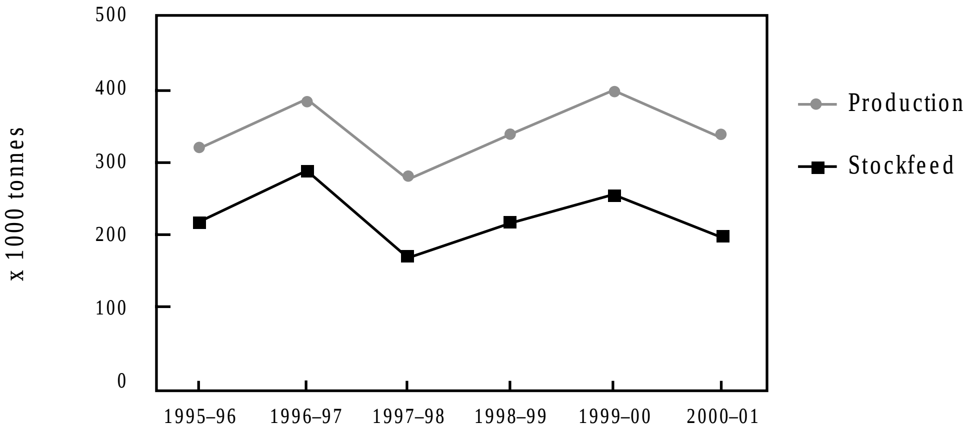

Figure 13. Australian production and domestic use of maize (Data source: ABARE 2002)

Maize with GM traits has been commercially grown in the USA since 1996. The USA dominates world production and export markets (AgWest 2002). In 2000, 7% of the 140 million hectares of maize produced worldwide had GM traits and this increased to 9% by 2002 (AgWest 2002; James 2002). Other countries that produce large quantities of transgenic corn are Argentina, South Africa and Spain (James 2002).

The USA does not segregate GM and non-GM maize and during severe droughts Australia may need to import maize for stockfeed. The maize supply chain for products entering the stockfeed supply chain increases in complexity from the other crops studied in this report because GM maize has already been imported from overseas. For example, Australia imported 45,000 tonnes of maize from the US in 2003 to provide feed for the poultry industry (Martin 2003). It is likely that GM maize has already entered the supply chain for stockfeed for the poultry industry in the recent drought. Although this did not affect the feedlot beef industry, there may be the potential for transgenic maize to be imported for this industry in the future.

8. Soybean products in stockfeed

8.1 The supply chain for soybean products in stockfeed

The three main soybean commodities are seeds, oil and meal and these may comprise up to 15% of the feedlot ration (DPI 2003a). Soybeans have high metabolisable energy and crude protein levels (DPI 2003a). Unprocessed soybeans have only limited stockfeed use as they contain toxicants and anti-nutritional factors including lectins and trypsin inhibitors although appropriate heat processing inactivates these compounds (ANZFA 2001).

In Australia, only non-GM soybean seed is available to growers. It is sown during Spring and early summer using a standard maize or peanut planter and the beans are harvested from April through to June (Pivot 2003).

Following harvest, soybeans are transported to storage facilities and then distributed to a crusher, stockfeed manufacturer or feedlot. Some soybeans and soybean hay may be sold directly from the producer to a feedlot (Figure 14).

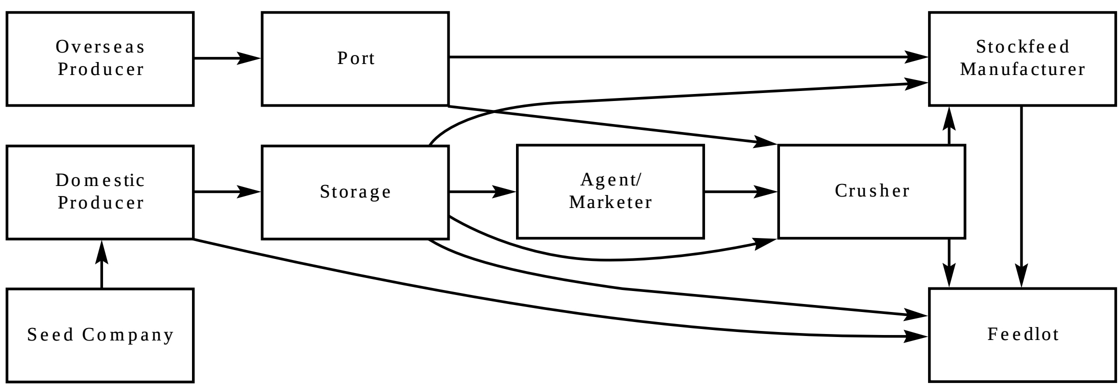

Figure 14. The supply chain for soybean products in stockfeed.

Soybeans are graded, cleaned, dried and dehulled before processing into food products. The hulls are a by-product of soybean processing for oil and meal and are included in the stockfeed ration. There are a variety of ways of processing soybeans that result in other by-products used in stockfeed products including:

- The extraction method, which begins with rolling de-hulled beans into full fat flakes. Crude oil is extracted from the flakes by immersing them in a solvent bath. Following the oil extraction, the solvent is removed and the flakes are dried and used for soy products. Both full fat and dried flakes can be used in stockfeed (Alphalink 2003);
- The extrusion method, which involves feeding the beans into an extractor barrel. This method uses heat generated by friction to destroy any trypsin inhibiting enzymes and the oil is not removed from the beans (Alphalink 2003);

- Roasting soybeans using a revolving finned cylinder to pass the beans through jets of flame (Alphalink 2003); and
- The expeller extraction system that heats the dried soybeans uniformly then uses an expeller press to extract the oil. Following oil extraction, the remaining soy flakes are ground into meal (Alphalink 2003).

The process for importing soybeans is the same as that outlined for maize.

8.2. Current and potential GM soybean inputs to the feedlot beef stockfeed supply chain

Soybean meal is an important source of protein for livestock in Australia and over 40% of meal consumption throughout the 1990s was by livestock (Nelson *et al.* 2001). Australia is not self-sufficient in soybeans and imports mainly from the USA where there is no segregation of GM and non-GM seeds (DPI 2003a, Thomas and O'Dea 2001).

Australia produced 100,000 tonnes of soybeans in 1999/2000 (Figure 15), whilst production in the US was 72.3 million tonnes and 20.7 million tonnes in Argentina (Nelson *et al.* 2001). In 2002 around 75-79% of the USA soybean harvest was from genetically modified varieties with GM beans being predominantly used in stock feed (PIBA 2001; James 2002).

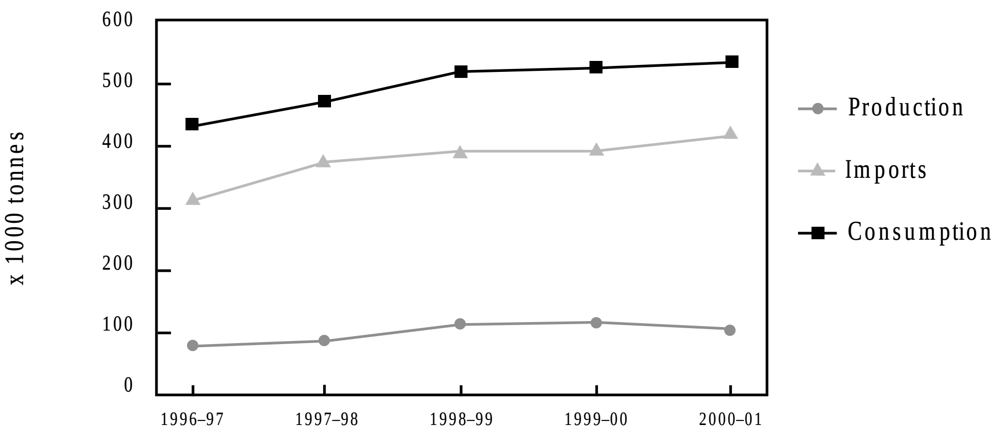

Figure 15. Australian production of soybeans, imports of soybean meal and consumption of soybean meal (Data source: Foster 2001).

In Australia, between 50,000 and 70,000 tonnes of soybeans are imported per year. Crushing beans are used almost entirely for animal feed production and account for 45 to 50,000 tonnes per year although this amount is declining over time as meal imports increase (PIBA 2001). 300,000 to 400,000 tonnes of soybean meal is imported annually and between 100,00 and 200,000 tonnes of this meal is used in feedlots (Figure 15) (Foster 2001; DPI 2003a).

The soybean supply chain is the most complex of the crops studied in this report because although only non-GM beans are grown in Australia, large quantities of potentially GM meal is imported for the stockfeed industry. Many products from soybean, such as tofu and soymilk enter human food. Consequently it is likely that segregation between GM and non-GM will be required to meet market requirements.

9. Discussion and conclusions

The feedlot beef stockfeed supply chain is a diverse set of supply networks which constantly change as lot feeders alter the composition and source of their rations to optimise nutrition and minimise cost. A single crop can be the source of several stockfeed ingredients including grains, seed meal, hay and silage. A single stockfeed ingredient can enter the ration through one of several pathways including directly from a domestic producer, via imports, through manufacturers of stockfeed or human food and via agents and marketers. Seasonal and regional factors will also influence the range of ingredients included in the stockfeed ration.

Of the six case studies reviewed above, the main sources of inputs to feedlot beef stockfeed are imported soy and domestically produced lupins. The quantity of each of the six crops produced and/or imported for stockfeed is summarised in Table 1. Although imported crops such as soybean are likely to contain GM, there is currently little or no segregation of GM and non-GM through the supply chain.

Table 1. Domestic production and consumption of six stockfeed commodities in 2000 (various sources cited in main text, * indicates potentially GM at present)

Crop	Domestic production	Consumption as stockfeed
Soybean*	105, 000	535,000
Lupins	800, 000	406,000
Canola	1,650, 000	258,000
Maize*	355, 000	205,000
Field peas	401,000	160,000
Cottonseed*	1,080,000	146,000

Given the wide range of supply chain arrangements potentially used by any one feedlot, it would be difficult for producers to assure customers that all ingredients used did not contain GM material if their rations contained cottonseed, imported soybeans or imported maize.

This situation is similar for livestock producers in Europe where soy and maize are imported without differentiation between GM and non-GM (Food Standards Agency 2001). In North America, there is little or no segregation of GM and non-GM soybeans, maize, cotton and canola used in stockfeed (Thomas and O'Dea 2001).

Since end point testing of animal products such as beef would not detect any differences that could be used to demonstrate the GM status of animal feeds then appropriate supply chain management arrangements would be required to guarantee the GM status of feed inputs.

In 2002, AFFA commissioned the Australian Government Analytical Laboratories (AGAL) to investigate testing methodologies to detect the GM content of commodities and food (Griffiths *et al.* 2002). Cost of testing and turnaround times that are considerations for commodities and foods would apply equally to stockfeeds. It is possible that tests may be developed which could be used to verify supply chain systems. Producers could then use test results to support a range of GM status claims, including GM-free, non-GM (e.g. less than a threshold of 1%) or low-GM (less than a threshold of 5%).

There are currently no GM feed crops commercially grown in Australia with the exception of cotton. The only other potential GM inputs to stockfeed identified in this study are imported soy and imported maize. If livestock producers using these three commodities were to be required to provide an assurance of GM status of feed inputs in future, they would require appropriate supply chain management systems to underpin this assurance to trace product through seed production, crop production, harvest, storage and the various marketing pathways. This discussion paper has highlighted some stockfeed ingredients that could originate from some GM crops.

The Gene Technology Grains Committee (GTGC 2002) reviewed the existing supply chain traceability systems for canola, from seed certification, through on-farm practices, transport, storage and processing. For canola, there are a variety of systems and standards that could be used for traceability throughout the supply chain including seed certification, detailed records, licences and crop management plans. This is predominately a private sector initiative with no legislative requirement but with strong community interest. In a related project, AFFA has engaged a consultant, Tasmanian Quality Assured Inc, to identify quality management systems that are relevant for the supply chain management of GM and non-GM products and to highlight the gaps.

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Appendix A.
Major components of feedlot beef stockfeed by crop

Table based on information from Blackwood *et al.* (2002) and Edwards (2000).

Crop	Product	Category
Adzuki beans	Beans	Pulses
Almonds	Shells	Milling offals and by-products
Barley	Grain	Cereals
Barley	Straw	Low protein dry roughages
Barley	Stubble	Low protein dry roughages
Barley	Brewers grains (dry)	Milling offals and by-products
Barley	Malt combings	Milling offals and by-products
Canola	Meal	Protein-rich concentrates
Chick peas	Peas	Pulses
Citrus	Pulp	Milling offals and by-products
Clover	Hay	High-protein dry roughages
Clover	Silage (mixed grass & clover)	High-protein wet roughages
Coconut	Meal	Protein-rich concentrates
Cotton	Hulls	Low protein dry roughages
Cotton	Meal	Protein-rich concentrates
Cowpea	Peas	High-protein dry roughages
Culinary beans	Beans	Pulses
Faba beans	Beans	Pulses
Field pea	Peas	High-protein dry roughages
Lablab	Beans	Pulses
Lentils	Beans	Pulses
Linseed	Meal	Protein-rich concentrates
Lucerne	Hay	High-protein dry roughages
Lucerne	Silage	High-protein wet roughages
Lupins	Lupins	Pulses
Maize	Hominy	Cereal grain by-products
Maize	Grain	Cereals
Maize	Silage	Low protein wet roughages
Maize	Stubble	Low protein dry roughages

Crop	Product	Category
Mung beans	Beans	Pulses
Oats	Bran	Cereal grain by-products
Oats	Hulls	Low protein dry roughages
Oats	Pollard	Milling offals and by-products
Oats	Straw	Low protein dry roughages
Oats	Stubble	Low protein dry roughages
Oats	Green fodder or silage (cut at flowering stage)	Low protein wet roughages
Oats	Hay	Low protein dry roughages
Oats	Grains	Cereals
Peanut	Hay	Low protein dry roughages
Peanut	Hulls	Low protein dry roughages
Peanut	Meal	Protein-rich concentrates
Peas	Pollard	Milling offals and by-products
Potato	Wastes	Milling offals and by-products
Rice	Grains	Cereals
Rice	Bran	Cereal grain by-products
Rice	Hulls	Low protein dry roughages
Rice	Pollard	Milling offals and by-products
Rice	Stubble	Low protein dry roughages
Rye	Grains	Cereals
Rye	Green fodder or silage (cut at flowering stage)	Low protein wet roughages
Safflower	Meal	Protein-rich concentrates
Sheep and cattle nuts	Nuts	Miscellaneous
Sorghum	Grains	Cereals
Sorghum	Hay	Low protein dry roughages
Sorghum	Silage	Low protein wet roughages
Sorghum	Stubble	Low protein dry roughages
Soy	Hay (75% pods)	High-protein dry roughages
Soy	Hay (full pods)	High-protein dry roughages
Soy	Hay (mature)	Low protein dry roughages
Soy	Meal	Protein-rich concentrates
Soy	Stubble	Low protein dry roughages
Sugarcane	Molasses	Miscellaneous
Sunflower	Meal	Protein-rich concentrates

Crop	Product	Category
Triticale	Grains	Cereals
Various	Confectionery	Milling offals and by-products
Various	Hay (mostly grass)	Low protein dry roughages
Various	Various	Oils
Various	Pomace	Milling offals and by-products
Vetch	Beans	Pulses
Wheat	Grains	Cereals
Wheat	Bran	Milling offals and by-products
Wheat	Green fodder or silage (cut at flowering stage)	Low protein wet roughages
Wheat	Pollard	Milling offals and by-products
Wheat	Straw	Low protein dry roughages
Wheat	Stubble	Low protein dry roughages
Wheat	Hay	Low protein dry roughages