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Alternative Energy Dense Feedstuffs for the Cattle Feedlot Industry

FLOT.101
Final Report prepared for MLA by:

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ISBN 1 74036 426 0

April 1997

FEEDLOTS

ALTERNATIVE ENERGY DENSE FEEDSTUFFS FOR THE CATTLE FEEDLOT INDUSTRY – Phase 1

April 1997

Feedlot Consistency and Sustainability Key Program
FLOT.101

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SUMMARY

This study examined the opportunities for utilising alternative energy dense feedstuffs in the Australian cattle feedlot industry. The study was initiated following the conclusion by the Meat Research Corporation's Feedlot Consistency and Sustainability Key Program, that the costs of energy dense feedstuffs currently used in the Australian feedlot industry are likely to rise in the future, and that this threatens the long-term prosperity of the industry.

An extensive review of potential feedstuffs was made and a short list of crops, products and by-products was prepared for more detailed assessment. Two criteria were used as the basis for this assessment. These were that the feedstuff must have a metabolisable energy (ME) equal to or greater than 10 megajoules per kilogram, and that the anticipated cost must be comparable with those energy sources currently used by the Australian feedlot industry.

In all, 21 products or by-products were selected for more detailed assessment and the results of those assessments are reported. The selected feedstuffs: fats and oils, white cotton seed (WCS), cassava, millets and forage crops, and commercial food wastes, comprised products and by-products of Australian agricultural and industrial origin and several imported crop products. Amongst the selected alternative energy sources are those capable of contributing to an increased efficiency in the established feedlot industry, and able to underpin an expansion into areas away from the current predominantly grain producing areas.

The selected feedstuffs included the fats and oils and WCS which appear to be generally underutilised in the established industry. The rapidly expanding cotton industry in northern Australia will ensure an increasing supply of WCS and this, in conjunction with other potential by-products and emerging purpose-grown crops, could meet the needs of an expanded feedlot industry. Further research is proposed to clarify aspects of the maximum inclusion rates for WCS, and their impact, if any, on carcase qualities.

Cassava also offers considerable promise as a high energy source. It is widely used internationally and protocols have been established for its importation from Asia. Whilst the protocols are yet to be tested, the indicated landed cost suggests that it could compete favourably with current feedstuffs, particularly in northern Australia. There could also be opportunities for growing cassava commercially in the Australian tropics and sub-tropics. This warrants a more detailed feasibility study.

Other potential energy sources identified in this study include the millets and the forage crops leucaena and sesbania. Several fibre crops, kenaf and sunn hemp, also offer potential as purpose-grown forage crops. A feature of all the forage crops is their rapid decline in feeding value with age. This necessitates the development of techniques to ensure the forage is harvested regularly at a young age. With all these crops further information is required to establish their potential to meet both harvesting, storage and processing requirements, while meeting the particular nutritional needs of the feedlot industry.

In addition to the above feedstuffs, there are substantial quantities of various commercial food wastes in the major population centres and horticultural areas. Little information is available on their quantities and quality, but they offer localised opportunities and warrant a closer examination.

Not surprisingly there appears to be no new product or by-product which would significantly hedge the Australian feedlot industry against future feedstuff cost fluctuations. However, those identified in this study offer real opportunities to increase the efficiency of the established industry and to buffer the industry against future grain price increases. They could also facilitate expansion of the industry into new areas.

The potential of the selected feedstuffs is discussed for three intensive cattle feeding situations namely: the **existing established feedlot industry**, a **future expanded feedlot industry** and an **intensive live cattle export support feeding industry**. Further research is detailed to clarify the issues of uncertainty for selected feedstuffs.

1. INTRODUCTION

1.1 BACKGROUND

The Meat Research Corporation's three-year Feedlot Consistency and Sustainability Key Program is aimed at increasing the profitability of the Australian cattle feedlot industry and developing cost-effective solutions to food safety, animal welfare and environmental imperatives within this sector of industry.

The program has identified a likely increase in the real cost of energy dense feedstuffs. Currently feedgrains are the principal source of nutrient metabolisable energy [ME], and their [in]security of supply is seen as a core problem affecting the long-term prosperity of the Australian feedlot industry.

The cost of energy dense feedstuffs used by the feedlot industry will increasingly be determined by global feedgrain supply and demand interactions. It is possible that existing crops, new purpose-grown crops, or the improved and expanded use of existing energy dense by-products, could have the potential to assist the industry by providing competitively costed alternative or complementary feedstuffs with enhanced security of supply. In addition, the identification of new feedstuffs may enable the industry to expand or develop away from the current predominantly grain producing areas to new locations. It may also facilitate specialised activities to assist live cattle export sales and value.

The Meat Research Corporation has initiated three studies. This study examines alternative energy dense feedstuffs for the Australian cattle feedlot industry. The others examine the expanded use of sugarcane by-products and high ME based silages.

1.2 PROJECT DEFINITION AND OBJECTIVES

The study is defined as ... *Phase 1 – A review and preliminary feasibility study of alternative crop and by-product options* ...as alternative energy dense feedstuffs for the cattle feedlot industry.

The objective of Phase 1 is to review past research and commercial experience and practice in Australia and overseas, and on the basis of this to:

- determine if it is feasible for potential feedstuff suppliers to grow new crops profitably, or better exploit by-product of existing crops, so that in the medium to long term the cattle feedlot industry can be supplied with lower cost ME than from traditional grain;
- identify any specific areas for research and development which may be required to unlock new supplies of high energy feedstuffs from commercial planting of alternative crops and/or better use of by-products.

2. AUSTRALIAN CATTLE FEEDLOT INDUSTRY

2.1 ESTABLISHED INDUSTRY

Initial interest in the feedlot fattening of cattle in Australia was stimulated in the early 1950s by observations of USA practice and experience with agro-industrial by-products and grains. Franklin (1957) foreshadowed the industry's nutritional knowledge requirements, and by 1958 Swift (Australia) Company Pty Ltd was operating a substantial feedlot with approximately 2000 head capacity at Tingalpa, Queensland. This followed feeding trials which commenced in 1954 and were based largely on several agro-industrial by-products (Biscoe 1960, 1961; Mawson and Sutherland 1960). In 1959 establishments based on grain as their principal nutrient source were operating in Central Queensland (Howard 1961) and near Warwick (Arbuckle 1960), indicative of the increasing interest in the use of grain to feedlot fatten cattle. Cattle were feedlot finished in North Queensland, near Ingham in 1959, and in 1960 the Kalamina Estate, Ayr, trialed feedlot fattening cattle with rations including sugar industry by-products, grain, meals, urea and minerals (Burns and Edwards 1963).

Several operating feedlots were intensively reviewed by Mawson and Arbuckle (1960) to highlight the principal economic aspects of feedlot fattening of cattle with particular reference to nutritional requirements and relative feedstuff values. The review examined a range of feedstuffs including grains, hays and by-products.

In NSW, greenchop and silages from irrigated crops were the basis of a permanent 1250 head capacity feedlot operated at Mudgee (Land 1963), and a similar 1500 head capacity unit established by Whale Industries Ltd near Deniliquin. Thus by the early 1960s there was considerable interest and experience in the feedlot fattening of cattle in Australia, using a range of feedstuffs.

The industry expanded in Eastern Australia during the dry seasons of the mid 1960s and in 1970 Pryor estimated the turnoff from Queensland feedlots to be 10,000 to 20,000 head annually (Pryor 1970).

The larger Australian professional feedlots began to be established in the 1970s, the first in NSW in 1972, based on steam flaked grains as the major source of ME.

2.1.1 Size, Capacity and Utilisation of Feedlots

The current industry is principally based on grain for its nutrient energy and has capacity estimated at about 867,000 head.

Table 2.1 Australian feedlot industry capacity

	NSW	VIC	QLD	SA	WA	Total
June 1996	292,485	68,050	428,284	40,732	31,500	**851,051**
September 1996	302,265	60,924	399,017	42,318	32,917	**837,161**
December 1996	304,404	58,523	401,454	41,001	30,178	**835,560**
March 1997	322,595	67,424	384,873	42,639	37,213	**854,744**
Est June 1997	336,688	66,866	384,362	42,761	36,513	**867,190**

Source: ALFA/AMLC

The breakdown of feedlot size by capacity has been estimated as shown in Table 2.2.

Table 2.2 Breakdown of feedlot industry cattle holding capacity by size

	Less than 500	500 - 1000	1000 - 10,000	Over 10,000	Total
June 1996	91,720	52,402	299,722	407,207	851,051
September 1996	85,985	68,183	281,744	401,549	837,461
December 1996	88,147	67,258	277,757	402,398	835,560
March 1997	84,236	74,542	288,966	407,000	854,744
Est June 1997	83,847	75,302	287,708	420,333	867,190

Source: ALFA/AMLC

In recent times there has been a decline in utilisation of feedlot capacity reflecting the state of market conditions, seasonal influences, and feedstuff costs (Table 2.3).

Table 2.3 Percentage utilisation of feedlot capacity 1995 to 1997

	NSW %	VIC %	QLD %	SA %	WA %	Total %
December 1995	56	59	59	65	32	56
March 1996	57	50	48	62	55	53
June 1996	45	54	39	26	42	42
September 1996	39	25	46	10	21	39
December 1996	50	23	46	13	32	44
March 1997	52	44	50	74	52	51
Est June 1997	50	68	52	63	48	53

Source: ALFA/AMLC

Feedlot capacity utilisation by size of feedlot has been estimated as shown in Table 2.4.

Table 2.4 Percentage utilisation of feedlot capacity by size

	Less than 500 %	500 - 1000 %	1000 - 10,000 %	Over 10,000 %	Total %
June 1996	14	30	35	55	42
September 1996	19	26	29	53	39
December 1996	25	32	31	59	44
March 1997	34	38	51	58	51
Est June 1997	29	42	53	59	53

Source: ALFA/AMLC

The distribution of feedlots with capacity less than, and greater than, 5000 head is illustrated in Diagrams 2.1 and 2.2.

Diagram 2.1
Feedlots with greater than 5000 head capacity

Source: MRC 1996

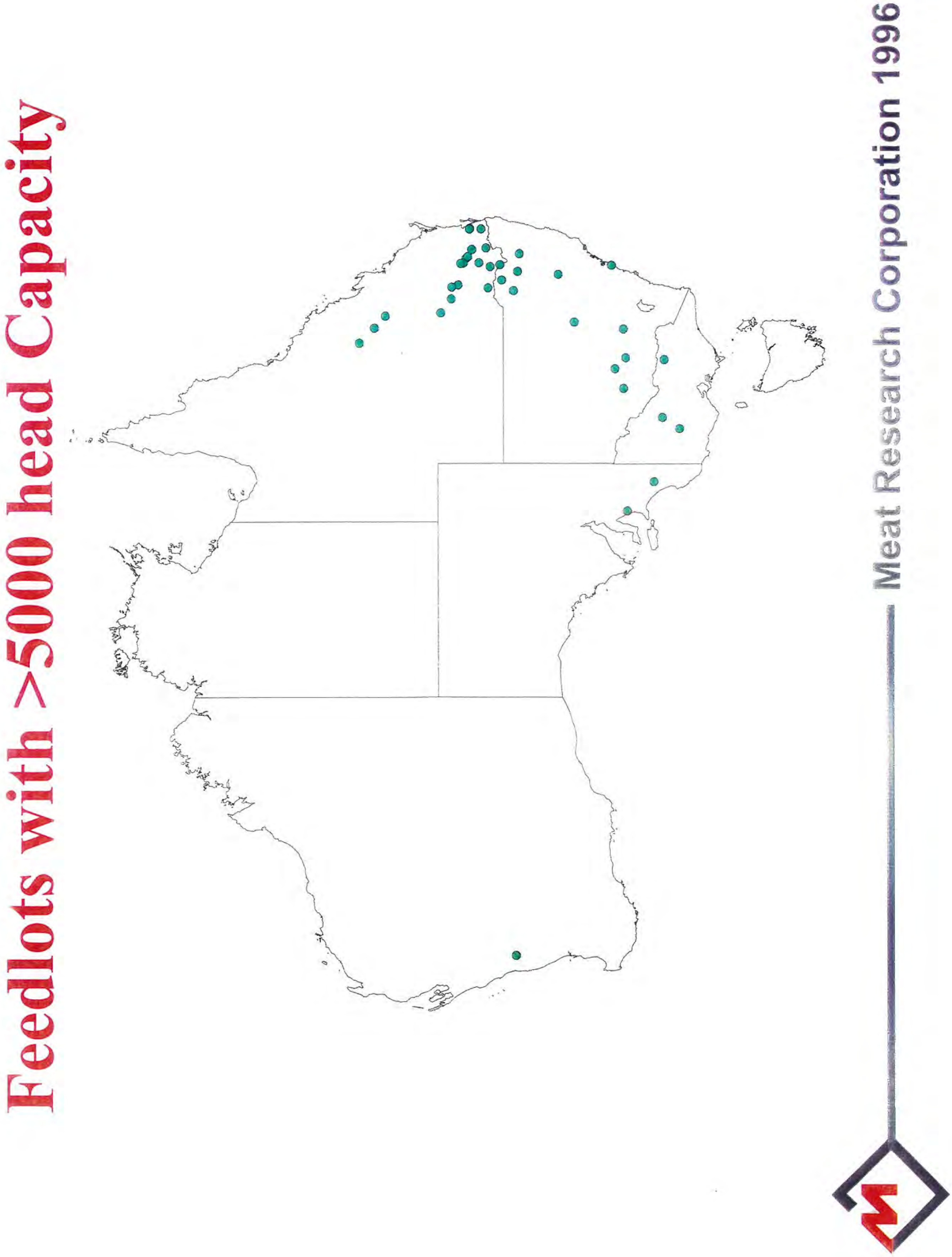
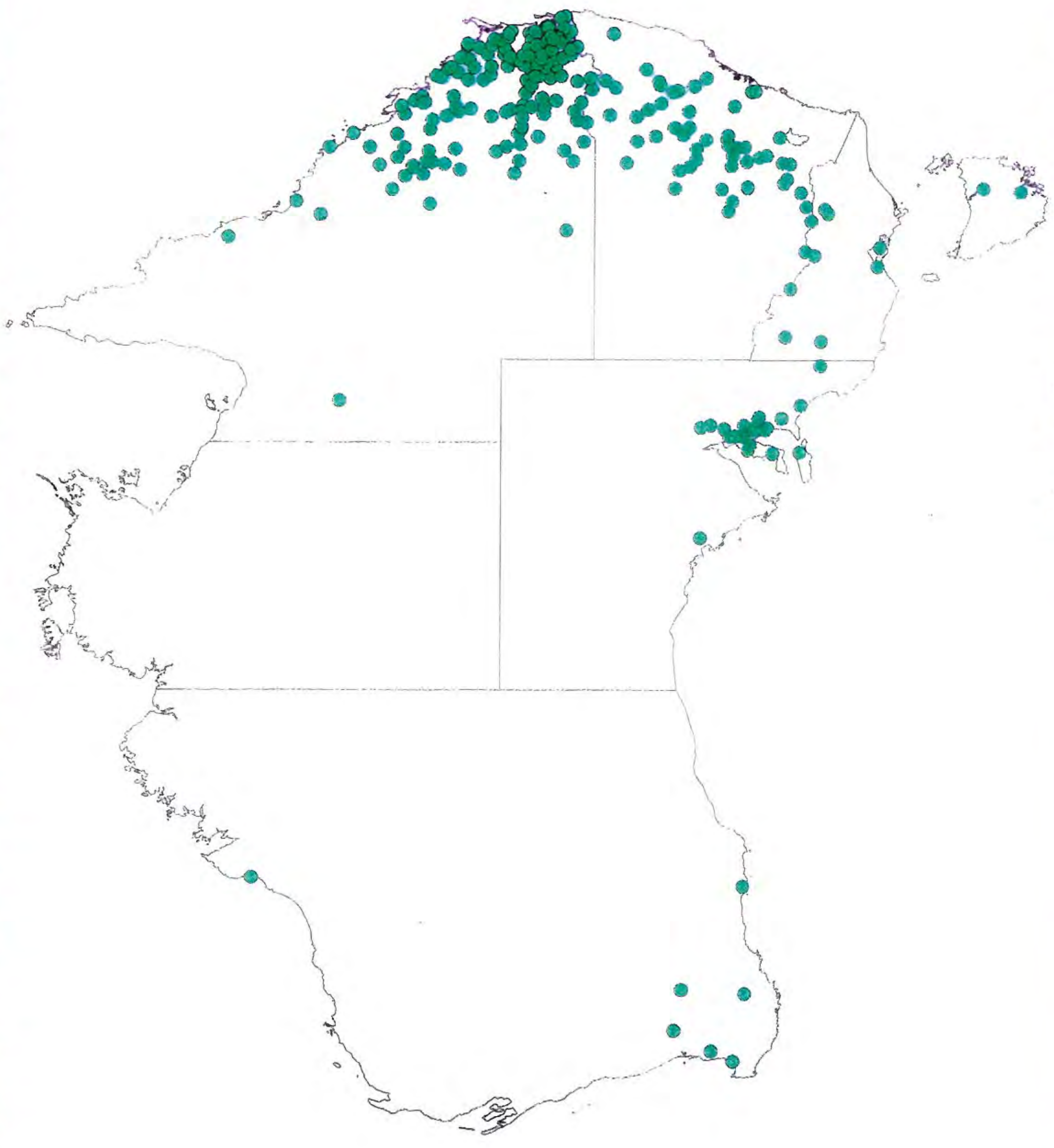


Diagram 2.2
Feedlots with less than 5000 head capacity

Source: MRC 1996

Feedlots with less than 5000 head capacity



Meat Research Corporation 1996

Feedlot capacity has expanded significantly in the period since 1990, with, until recently, market demand ensuring reasonably high capacity utilisation. In 1994 the utilisation was estimated at 73% (MRC 1995). In March 1997 it was 51%, having recovered from a low of 39% in September 1996.

2.1.2 Feedstuff Consumption

The feedlot industry feedstuff consumption was estimated in 1994 as shown in Table 2.5.

Table 2.5 Consumption of feedstuff in 1992-93 and 1993-94

	1992-93		1993-94	
	'000 tonnes	%	'000 tonnes	%
Sorghum	265	18.0	205	10.0
Barley	523	35.0	782	37.0
Wheat	181	12.0	376	18.0
Other Grains	63	4.2	61	3.0
Molasses	57	3.8	86	4.0
Other Concentrates	104	7.0	134	6.0
Cotton Seed Hulls	73	5.0	50	2.0
Other Roughage	236	16.0	419	20.0
TOTAL	1,503	100.0	2,173	100.0

Source: ALFA/AMLC

Grains, the principal source of ME, represented 69% and 68% of feedstuffs consumed in the observed periods. Meyers Strategy Group (1995) determined that feedstuff costs represented 88% of total feedlot production costs, and that grain comprised some 80% of feedstuff costs. Others (MRC 1993) reported feedstuff costs as 84% of feedlot production costs. Thus feedgrain costs, normally representing some 65% to 70% of total feedlot production costs, have a significant impact on the overall cost of production and profitability in the Australian feedlot industry.

Meyers Strategy Group (1995) estimated the Australian feedlot industry accounted for 23% (1,672,000 tonnes) of domestically consumed feedgrains in 1992-93. In 1994 it was assessed (MRC 1995) the feedlot industry required 1,506,000 tonnes of feedgrains annually, representing 28% of the estimated 5,453,000 tonnes then used by all Australian domestic livestock industries. The development of the feedlot industry and increased use of feedgrains in the dairying industry (expanded to 1,175,000 tonnes annually) had doubled the domestic demand for feedgrains over the previous ten years to 1994.

While feedgrain supply has met demand in normal seasons to date, regional feedgrain shortages have emerged under extreme drought conditions, particularly in Queensland. With domestic feedgrain demand (5,453,000 tonnes, 1994) increasing in relation to exports (3,500,000 tonnes, 1994) the feedlot industry has moved (with other grain users in the domestic market) towards being a price taker rather than a price maker, for its major source of nutrient energy, and major feedlot production cost item.

2.2 DEVELOPMENTS

The medium term objective of the Australian feedlot industry is to provide increasing numbers of finished cattle to meet the growing demand for grain fed beef in both domestic and export markets.

The industry is expected to recover from its current depressed state of activity and to increase production above 1994 levels to the year 2000 and beyond. Projected total beef production increases range between 11% (pessimistic) and 18% (optimistic) with exports increasing between 14% and 29% respectively (MRC 1995). A disproportionately greater amount of this increase will be from the feedlot industry, which will experience continued competition from US exporters in established Australian grainfed beef markets.

While the dairy industry is projected to experience the greatest increase in demand for feedgrains to the year 2000, the feedlot sector is still predicted to be the largest user of feedgrains (Meyers Strategy Group 1995). Meyers concluded that at the national level, provided the Australian feedlot industry is prepared to meet world prices, the industry's projected requirements for feedgrains should be able to be met. However, the constraints of climatic variability may impose occasional severe droughts which could limit supplies in some regions.

The regional feedgrain supply/demand situation is expected to vary considerably between regions. These regional variations can be broadly defined as follows:

- Central Queensland / South Australia / Western Australia grain industries will remain export oriented;
- Victoria / Southern NSW will become increasingly oriented to the domestic intensive livestock industries;
- Northern NSW / Southern Queensland will remain a net regional importer in most years.

The recent phenomenal growth in the northern Australian live cattle export trade principally involves feeder cattle destined for the expanding feedlot industries in South East Asia. In excess of 500,000 head, or over 70% of Australia's live cattle exports were loaded out of northern Australian ports in 1996.

Most stock originate from the Northern Territory and are shipped via Darwin, with increasing numbers moving from northern Western Australia and Queensland, including east coast seaports (Table 2.6).

Table 2.6 Live cattle exports from Australia in 1996

Load Port	Total Cattle Exports
Adelaide	29,273
Brisbane	14,391
Broome	24,072
Cairns	4,930
Devonport	3,569
Darwin	384,045
Fremantle	52,944
Geraldton	29,215
Karumba	55,295
Melbourne	474
Portland	7,356
Perth	20
Port Hedland	13,481
Sydney	4,449
Townsville	765
Wyndham	38,033
TOTAL	**723,085**

Source: ALFA/AMLC

As the Asian feedlot industry becomes increasingly sophisticated it can be expected to place greater emphasis on size, quality and condition of stock on arrival. Animal health, and the reliability, suitability and consistency of supply will increasingly be price determinants.

Conceivably, a specialised support feeding industry will develop in northern Australia to hold, grow out, and prepare cattle for live export shipments, provided suitable feedstuffs are available at commercially acceptable costs.

Such a support feeding sector could be less capital intensive than the established feedlot industry, involving feeding stock for a range of feeding periods to better meet the live cattle market requirements. The feeding regimes will, however, remain dependent on relatively high energy feedstuffs sourced locally, which currently are not readily available. This study addresses this need and highlights several feedstuffs with potential to provide part of the ration requirements.

3. STUDY METHODOLOGY

3.1 GENERAL APPROACH

We have defined an energy dense feedstuff as one having a metabolisable energy (ME) greater than or equal to 10MJ/kg.

The ME of current commonly used feedstuffs, and the cost range of ME for a range of feedstuff values are illustrated in Table 3.1. In these examples, the cost of ME ranges from $0.73 to $2.35 / 100MJ. This data provides an important comparison for alternative feedstuffs examined in this study.

Table 3.1 Feedstuff cost ranges ($/tonne) and metabolisable energy costs ($/100MJ of ME) for feedstuffs currently used by the Australian feedlot industry

Feedstuff		Cost Range ($/tonne As Is)			Dry Matter	Dry Basis (100% Dry Matter)							
						Cost Range ($/tonne)			Metabolisable Energy		Cost Range of ME ($/100MJ of ME)		
		(a)	(b)	(c)	%	(a)	(b)	(c)	MJ/kg	(Mcal/kg)	(a)	(b)	(c)
Barley	Grain	100	**150**	200	88	114	**171**	227	**13.0**	3.1	0.87	**1.31**	1.75
Maize	Grain	125	**200**	275	88	142	**227**	313	**13.7**	3.3	1.04	**1.66**	2.28
	Silage	35	**45**	55	37	95	**122**	149	**10.3**	2.5	0.92	**1.18**	1.45
Molasses		60	**90**	120	77	78	**118**	157	**11.0**	2.6	0.71	**1.07**	1.43
Sorghum	Grain	100	**150**	200	88	114	**170**	227	**12.0**	2.9	0.95	**1.42**	1.89
Wheat	Grain	125	**200**	275	88	142	**227**	313	**13.3**	3.2	1.07	**1.71**	2.35

Note: An indicative price range is illustrated by (a) Low (b) **Medium** (c) High

Initially, a preliminary list was compiled of crop and by-product feedstuffs able to be produced under Australian conditions, or able to be imported, and capable of meeting the criterion of having an ME of 10MJ/kg or higher. This is presented as Appendix 1 Energy Dense Feedstuffs.

The ME of a feedstuff is thus a key determinant in this study of the product's suitability. It should be recognised that in practice, the actual ME of a particular product is influenced by many factors: cultivar, stage of growth, the plant part, form of any processing (ensiling, grinding, rolling, extraction process, etc), soil type and season.

In reality, the ME value is only one factor in evaluating a feedstuff. Nutrient protein, mineral and vitamin properties are routinely concurrently assessed when applying least-cost ration formulation and least-cost of gain principles, and/or importantly maximising return on funds employed. For the purposes of this study, these properties were not closely examined but where available they were included in Appendix Table 1, to assist the initial evaluation.

Additional criteria when evaluating feedstuffs include:

- cost
- physical properties (density and DM for example, directly affect freight and storage costs)
- palatability and acceptability to animal
- availability, security and continuity of supply
- seasonality
- processing requirements
- likelihood of chemical or other contamination
- specific infrastructure needs and availability (transport, storage, processing)
- likely competition from alternative markets
- possibility of environmental or other limitations on production.

Of these, the feedstuff cost is clearly of major importance, and this was included in the preliminary evaluations where possible. It should be noted that for each specific use situation, costs will vary depending on the supply source, feedlot location, season, order size, quality, freight, storage and handling facilities, and factors beyond reliable prediction.

The costs presented in Appendix Table 1 provide a basis for comparison with currently used feedstuffs (Table 3.1). These can be expected to move in sympathy with domestic and international feedstuff market demand and supply situations, and substitution opportunities.

3.2 SELECTION CRITERIA

The crops and by-products included in the preliminary list were assessed against two primary selection criteria: - metabolisable energy (content), and
- cost.

A full listing of the crop and by-products considered is given in Appendix Table 1. Also included in this table is an indication (where available) of the products' capacity to contribute to ration quality (special qualities) and their potential for use (category).

Special qualities:

CP	....	can significantly contribute to the ration crude protein nutrient component.
Min	....	can significantly contribute to the ration mineral component.
Phy	....	can significantly contribute to the ration physical qualities.

Category:

P	....	promising, ME exceeds 10MJ/kg.
M	....	marginal, ME between 8.5 and 10MJ/kg, but has special qualities.
Uc	....	generally limited potential, due to high cost of production.
Us	....	generally limited potential, due to supply considerations (may be specific opportunities).
Ue	....	generally limited potential, due to low ME.
Um	....	generally limited potential, due to high value market alternatives.

From the preliminary list a short list of potential feedstuffs was produced (Table 4.1). Each of these potential feedstuffs was then examined in detail. Individual assessments are given in Appendix 2 Identified Feedstuffs.

The findings from the individual assessments were then used to select a final list, Table 4.2, of crops and by-products with potential for use in the intensive feedlot industry.

3.3 FUTURE RESEARCH AND DEVELOPMENT

Chapter 7 identifyies the research and development needed to overcome constraints and limiting factors in the expanded use of alternative energy dense feedstuffs in the Australian cattle feedlot industry.

4. SELECTED FEEDSTUFFS FOR FEEDLOT USE

4.1 GENERAL

In developing the short list of crop and by-product feedstuffs (Table 4.1), a lateral approach was adopted. A number of new crops which appear to have real potential as future feedstuffs for the feedlot industry were included. Some of these could be grown as purpose-grown crops while others are by-products.

At the same time, feedstuffs which are already common components of feedlot rations, such as the feed grains and meals, were excluded, as were maize silage and molasses, the subjects of separate specific studies.

The short list also excluded those crops and by-products categorised as unlikely to be suitable due to high cost of production, supply considerations, or low ME, and those for which there are alternative high value markets, such as for human consumption. Feedstuffs likely to cost in excess of $2.50/100MJ of ME were also excluded, unless of special interest.

The identified short listed feedstuffs are grouped in Table 4.1 with respect to their origin.

Table 4.1 Identified feedstuffs for feedlot use

Agricultural Origin – Australia	
• Cassava	As processed tubers
• White Cotton Seed	By-product
• Millets	As grain or forage crop
• Kenaf	As forage crop
• Sunn Hemp	As forage crop
• Leucaena	As forage crop
• Sesbania	As forage crop
• Chickpeas	As grain or forage crop
• Cowpeas	As grain or forage crop
• Lucerne	As forage crop
• Temperate Pasture Species	As forage crop
• Tropical Pasture Grasses	As forage crop
• Pineapple	By-product
• Potato	By-product
• Lablab	As grain or forage crop
• Sugar Beet	Root crop
Agricultural Origin – Imported	
• Cassava	As processed tubers
• Copra Meal	As meal
• Oil Palm Meal	As meal
Industrial Origin – Australia	
• Fats and Oils	By-product
• Commercial Food Wastes	By-product

Each of these shortlisted feedstuffs was assessed rigorously with a view to identifying those with specific potential. Appendix 2 provides the details of these assessments. It includes a description of the crop or product, aspects of nutritional properties, production and/or supply, costs, feedlot utilisation, and research and development needs.

4.2 SELECTED ENERGY DENSE FEEDSTUFFS

The feedstuffs selected for further study on the basis of the detailed assessments, possess either the potential for immediate or increased use by sectors of industry, or special attributes which warrant further investigation.

The selected feedstuffs are:

• **FATS and OILS**		By-product
• **WHITE COTTON SEED**		By-product
• **CASSAVA, imported**		Tuber
• **CASSAVA, locally grown**		Tuber
• **MILLETS**		Cereal
• **FIBRE CROPS**	- kenaf	Forage crop
	- sunn hemp	Forage crop
• **SHRUB LEGUMES**	- leucaena	Forage crop
	- sesbania	Forage crop
• **COMMERCIAL FOOD WASTES**		By-product

These selected feedstuffs present the potential to increase efficiency in much of the existing industry as part ration components, and/or to assist the cattle feeding industry's expansion away from the predominantly grain producing areas to new locations. Within this broad finding, the following particular opportunities and constraints are noted.

- Commercial food wastes, and the by-products from the growing and processing of pineapple, potatoes and other human feedstuffs, may offer localised opportunities for a limited industry segment.

- The opportunity to incorporate the identified imported by-products of oil palm kernel meal and copra meal as sources of energy is dependent on landed costs. Their potential is considered to be generally marginal, although it could be favourable on occasions.

- Lucerne and the pulses chickpeas and cowpeas may offer marginal specialised local opportunities, as might selected temperate and tropical pasture species, but in the overall industry context their potential use appears limited. The root crop sugar beet and the pulse lablab bean were rejected on the basis of cost.

4.3 SWOT ANALYSES FOR THE SELECTED FEEDSTUFFS

The SWOT analyses for each selected feedstuff have been extracted from the detailed assessments in Appendix 2 and are presented below. These provide a summary of the merits of the various by-product and crop feedstuffs.

4.3.1 Fats and Oils

SWOT Analysis

Strengths

- Very high energy dense feedstuff able to improve ration quality.
- Enhances palatability by improving ration structure.
- Suppresses dust.
- Lubricates feed processing equipment.
- Is easily handled and stored once suitable infrastructure is established.
- Offers consistent supplies.

Weaknesses

- Presents risk of impurities, contaminants, toxins.
- Requires specific purpose-designed infrastructure.
- Has upper use level of probably 5%. (Total dietary fat is a necessary consideration.)
- Requires attention to quality and handling to avoid rancidity.
- Is subject to considerable variations in cost.
- Requires QA monitoring.

Opportunities

- Offers energy dense feedstuff at favourable ME cost.
- Enhances ration quality and feed use efficiency.
- Can improve ration physical properties.

Threats

- May contain contaminating toxins or chemicals.

Conclusion

Fats and oils are energy dense feedstuffs whose cost frequently makes them a most attractive ration component and source of ME. Their inclusion in Australian feedlot rations can almost certainly be extended when competitively costed.

4.3.2 White Cotton Seed

SWOT Analysis

Strengths

- High energy feedstuff with associated high protein levels.
- Competitively costed source of ME.
- Very palatable.
- Easily handled, transported and stored.
- With current production practices appears to have no problems of chemical residues.

Weaknesses

- Can combust spontaneously if stored too wet (less than 86% DM) and heaped too high.
- May develop *Aspergillus* mould, producing aflatoxins, when stored moist.

- High WCS may conflict with high supplemental fat levels in ration.
- Virtually unknown maximum inclusion level in rations in Australia.
- May lead to harder carcase fat (anecdotal evidence).

Opportunities

- A potentially under-utilised high energy feedstuff in Australian feedlot industry.
- Increasing supplies expected as Australian cotton industry expands, particularly in northern Australia.
- Treatment with products such as dunder, improves its handling ability for special situations.
- Potentially valuable feedstuff component in rations for live cattle export markets in northern Australia.

Threats

- In some areas, increased competition from dairy industry usage is likely.
- Unknown possible effects on carcase qualities at high inclusion levels in ration.
- Unknown practical maximum inclusion rates.

Conclusion

WCS is a palatable energy-dense feedstuff with associated high protein content, widely available in Eastern Australia at ME costs comparing favourably with currently used ration components. Currently, the feedlot industry uses some 80,000 to 100,000 tonnes annually. There appears to be scope for WCS to be used at higher levels in many instances when competitively costed.

Increasing quantities of WCS will be available in Queensland and northern Western Australia as the cotton industry expands, and this could have positive implications for live cattle export and the feedlot industry in northern Australia.

4.3.3 Cassava (Imported)

(See also 4.3.4)

SWOT Analysis

Strengths

- High energy feedstuff widely used in Asia and Europe.
- AQIS advise protocol to import from Thailand in place.
- Reasonably costed source of ME.
- Very palatable.
- Can replace up to 30% of DM in growing-finishing rations.

Weaknesses

- Protocols for importation have only recently been developed and no product has yet been imported.
- Low protein, mineral, vitamin levels.
- Maximum practical ration component is 25% to 30% DM.

Opportunities

- Develop a protocol for importing from South Pacific Islands, eg. Fiji, whose supplies may be cheaper.
- Develop production and processing operation in South Pacific Islands. The Fiji government is presently seeking to establish new joint venture operations.
- May be a useful high energy feedstuff in north Australian rations.

Threats

- Currently, supply limitations.

Conclusion

Cassava is also reviewed (Section 4.3.4) as a potential crop for Australian production.

Cassava has only recently been able to be imported from Thailand, and to date this has been of little consequence to the Australian feedlot industry. In the future the South Pacific nations, such as Fiji, appear to offer better prospects for production.

Cassava is a potentially useful source of ME in feedlot rations, in particular in northern Australia, as a part ration component, favourably costed compared with currently used feedstuffs (Table 3.1).

4.3.4 Cassava (Locally grown)

(See also 4.3.3)

SWOT Analysis

Strengths

- High energy feedstuff widely used in Asia and Europe.
- Very palatable.
- Cassava is reputed to produce more starch/hectare under relatively dry conditions than any other crop.
- Cultural requirements for optimal production have been established.
- Suitable planting and mechanical harvesting equipment have been developed.
- Harvest date is not critical, and harvesting can be spread over a fairly long period.
- Processing is simple, infrastructure needs are not large.
- Rarely subject to serious pest and disease problems.
- Little risk of chemical contamination.
- Dried chips are suitable for bulk handling and are readily transported and stored.

Weaknesses

- May compete for land use with sugarcane.
- The crop is slow growing, reaching maturity at 18 to 24 months.
- Harvesting of the deep tubers is slow and costly and poses an environmental risk via soil damage and possible erosion.
- Grows best on light, sandy soils which are relatively rare in areas of Australia with a suitable climate.
- There is a lack of information on yield and production costs in Australia despite earlier trial work.

Opportunities

- High yielding, high nutrient energy crop, well adapted to production in tropical and sub-tropical Australia where grain feedstuffs are difficult to produce.
- May be a suitable high energy feedstuff to grow away from sugarcane areas in northern Australia.

Threats

- May compete with sugarcane for land use. As sugarcane is a well established, relatively simple crop to grow it would need to produce comparable returns or better to become a viable industry in the established farming areas.
- Chemical contamination from adhering soil.
- Soil damage.

Conclusion

Cassava is also reviewed (Section 4.3.3) as a possible import into Australia.

Cassava is already widely grown in many countries and used as an energy-dense stock feed. It appears a promising crop to grow locally as a potential new source of ME for feedlot operations. Cultural requirements have been well researched in Australia.

Preliminary estimates by the University of Queensland using a computer-based cassava growth model indicate that there are some 600,000 hectares with suitable soil and climate for cassava production in Queensland. Much of this is beyond the established farming areas. There are also large areas of suitable land in the Northern Territory and northern Western Australia.

There are no reliable data on production costs for Australian conditions.

4.3.5 Millets

SWOT Analysis

Strengths

- 'Millets' comprise a range of high energy grains.
- A wide range of genetic material is available for most species.
- Many varieties are promising sources of grain in northern Australia.
- All millets appear to be tolerant of water stress, are well adapted to a wide range of soils, and are capable of producing on low fertility soils.
- The small seed of millet reduces seeding costs.
- Millets are apparently not subject to serious pest and disease problems.
- They are robust, deep rooted and more resilient than sorghum.
- No major environmental or chemical residue problems are envisaged.

Weaknesses

- Milling of small grain is difficult.
- Little research has been done in Australia, particularly in northern Australia.
- Yields vary widely with species, and are generally lower than for established cereals.
- Limited information is available on agronomic requirements for mechanised production in Australia.

Opportunities

- Potential significant source of grain and high energy feedstuff over much of northern Australia, where current cereal grains perform poorly.
- Drought resistance provides potential for extending crop production to lower rainfall areas.

Threats

- High value of existing varieties of grain for bird seed trade and as novelty foods.

Conclusion

Millets offer the quite strong possibility of extending grain production into the lower rainfall semi-arid tropics and sub-tropics, and, as such, could be significant sources of high energy feedstuffs in northern Australia.

There is little information on the use of millets for hay or silage production, but the high ME of the grain suggests that hay or silage cut at about the soft dough stage for grain production would be a useful high energy feed.

4.3.6 Kenaf

SWOT Analysis

Strengths

- Reasonable ME source when harvested young.
- Very fast growing and high yielding over a range of soils and climates.
- Extensively researched in Australia enabling easy selection of suitable cultivars and cultural practices.
- Well adapted to summer rainfall areas providing complete ground cover, eliminating weeds and reducing the risk of soil erosion.
- Tolerant of water stress and of moderate salinity.
- Without serious pest or disease problems.
- Can be grown and harvested with conventional farm machinery.

Weaknesses

- Harvesting and processing procedures need to be developed and refined.
- The large biomass production requires high fertiliser inputs.
- Relative low density of hay incurs higher cartage, storage and processing costs; double dumping of bales may assist.
- Unless purpose-grown, leaf could only be utilised as a feedstuff if produced as a by-product of a pulp and paper industry.

Opportunities

- A crop which can excel in northern Australia as a purpose-grown hay crop, or as a crop grown as a pulping feedstock.
- A non-woody fibre crop alternative providing a reasonable nutrient energy source in its leaf by-product for farmers seeking to diversify production systems.

Threats

- Development of a kenaf leaf by-product meal industry would be dependent on the successful establishment of an associated pulp and paper industry.

Conclusion

Overseas feeding trials suggest that kenaf leaf and edible stem material have potential as an energy source feedstuff for cattle. Kenaf, purpose grown as a forage crop and harvested at about 60 days, offers the prospect of a relatively high energy feedstuff able to be grown over much of Australia, particularly in the north under irrigation, or dryland where rainfall is adequate.

Kenaf leaf meal could also become available as a by-product if a pulping industry was established in close proximity to feedlot enterprises.

4.3.7 Sunn Hemp

SWOT Analysis

Strengths

- Potentially a hardy tropical or sub-tropical crop offering a reasonable level of ME.
- Will grow on poor soils and is fairly drought resistant.
- In some varieties, has a high level of resistance to root knot nematodes.
- As a legume can fix atmospheric nitrogen to meet its nutrient requirements.

Weaknesses

- Has posed problems in obtaining good crop stands.
- Shows some tendency to lodge.
- Is sensitive to cool temperatures.
- Offers lower yields than other fibre crops, eg. kenaf.

Opportunities

- A potential early-harvested energy feedstuff for northern Australia.

Threats

- No serious threats apparent.

Conclusion

Although little is known of sunn hemp in Australia, it appears to have prospects as a forage crop in northern Australia, or as a by-product of a paper pulp industry, in common with kenaf.

4.3.8 Leucaena

SWOT Analysis

Strengths

- Source of dry matter with reasonable energy and crude protein levels in northern Australia.
- On assumptions made regarding ME, it appears a reasonably costed source of ME.
- A long-lived perennial capable of producing a high DM yield with regular forage harvesting.
- Suitable agronomic and management practices have been established, and preliminary mechanised harvesting systems have been developed, at research level.

Weaknesses

- Costs of production, harvesting and storage are unknown.
- Current cultivars (and thus established stands) are susceptible to psyllid.
- Psyllid resistant cultivars becoming available may have different nutritive value than current cultivars.
- Fertile, well drained soil is required for high production.
- Successful establishment can be difficult.
- No commercially proven harvesting methods or storage systems are available, although research to date is promising.
- Toxicity is possible due to mimosine/DHP.
- Transport from farm to feedlot may be expensive.

Opportunities	• In northern Australia there are an estimated 2,000,000 hectares suitable for leucaena establishment.
	• Mimosine/DHP toxicity can be prevented with rumen inoculation of 10% of stock.
	• There is potential for higher yielding psyllid resistant cultivars.
	• Suitable commercial harvesting from hedgerows could be developed.
	• Suitable processing and storage technology could be developed (eg. pelleting).
Threats	• Psyllid attack.

Conclusion

Leucaena is a potential source of ME in northern Australia as a purpose-grown crop but harvesting, processing and storage practices need to be further developed. Currently, there is a lack of applied production knowledge limiting its commercial development for the feedlot industry.

4.3.9 Sesbania

SWOT Analysis

Strengths	• Reasonably high energy feedstuff with potential for northern Australia.
	• Is readily established from seed and fast growing on a wide range of soil types and moisture conditions.
	• Appears subject to few diseases and unattractive to most insect pests.
	• Presents low risk of chemical residues.
	• Offers the benefit of a large germplasm collection in Australia..
Weaknesses	• Cost of production is unknown.
	• The most promising forage species appear to have a fairly short lifespan (about two years).
	• Information on growth and yields under intensive harvesting is lacking.
	• Commercial harvesting, processing and storage systems need to be developed.
	• Information on the likely viability of a production system is unavailable.
Opportunities	• Could form the basis of a large-scale tropical forage industry for the feedlot or associated industries.
Threats	• No serious threats can be foreseen at this stage.

Conclusion

Sesbania is a forage species offering promise as a feedstuff for a feedlot industry in northern Australia. Its tolerance of poor soil conditions, its capacity to fix nitrogen and its apparent resistance to insect pests and diseases are valuable attributes. However, research and development work is required to assess its potential as a commercial feedstuff.

4.3.10 Commercial Food Wastes

SWOT Analysis

Strengths
- Potentially large quantity of high energy feedstuffs at possibly low cost.

Weaknesses
- Lack of knowledge of what, how much, where, and in what form the wastes exist.
- Much of the feed wastes, estimated at 50%, might be unacceptable due to contaminants (physical or chemical).
- Usually sourced in urban and industrial areas.
- Often low DM content.

Opportunities
- Study and define food wastes, their source and characteristics, and determine use.
- Assess quantity and costs of potential feedstuffs.
- If practical and feasible, develop transport, storage and feeding systems utilising feed waste.
- Provide an opportunity to remove current and future environmental problems associated with waste removal.

Threats
- Contaminants, though risks can be minimised by effective quality control practices.
- High moisture content common and hence freight and storage difficult.
- Inadequate information on nutrient values.
- Competition for usage from other intensive livestock industries nearer urban fringe (dairy, pigs, etc).

Conclusion

While there appears to be a very large proportion of the food wastes which could be suitable for ultimate inclusion in cattle fattening rations, there is in reality no knowledge of what, where, when and how much is available, or of its nature, supply and consistency pattern.

It appears the majority of these wastes are currently discarded. The exceptions are possibly brewers grains used in dairy and minor cattle feedlot operations, cannery and vegetable processing wastes, and some confectionery wastes used in pig production units. Some wastes are used in fringe urban livestock units, occasionally operating illegally, but much is discarded at a cost.

A study of commercial food industries and their wastes appears warranted to clarify their possible contribution.

4.4 COMPARATIVE SELECTED FEEDSTUFFS COSTS FOR A RANGE OF ME COSTS

For comparative purposes, the feedstuffs are evaluated on a range of ME costs.

The comparative feedstuff cost ranges for several costs of ME are illustrated in Table 4.2 enabling feedstuff values as a source of ME to be compared for the assumptions made. For example, barley grain at $143.00/tonne is a source of ME at $1.25/100MJ, as are WCS at $167.00/tonne and fats and oils at $439.00/tonne. WCS at a lower cost than $167.00/tonne or fats and oils at less than $439.00/tonne are cheaper sources of ME than barley at $143.00, all other factors disregarded. Similarly, maize silage at a cost greater than $48.00/tonne is a more expensive source of energy than barley at $143.00/tonne.

Table 4.2 can be customised for a range of circumstances.

Table 4.2 Illustrative comparative selected feedstuff cost ranges ($/DM tonne, $/tonne As Is) when ME costs are $0.90/100MJ, $1.25/100MJ and $1.60/100MJ

FEEDSTUFF		Metabolisable Energy (Indicative DM Basis)		Feedstuff Opportunity Cost ($/tonne DM)			Dry Matter	Feedstuff Opportunity Cost ($/tonne As Is)		
Name	Description	Range (MJ/kg)	Assessed (MJ/kg)	ME $0.90/100MJ	ME $1.25/100MJ	ME $1.60/100MJ	%	ME $0.90/100MJ	ME $1.25/100MJ	ME $1.60/100MJ
As Illustrated Table 3.1										
BARLEY	Grain	12.7-13.7	**13.0**	117	**163**	208	88	103	**143**	183
MAIZE	Grain	13.5-14.2	**13.7**	123	**171**	219	88	109	**151**	193
	Silage	9.2-11.3	**10.3**	93	**129**	165	37	34	**48**	61
MOLASSES		10.9-12.7	**11.0**	99	**138**	176	77	76	**105**	135
SORGHUM	Grain	11.0-13.4	**12.0**	108	**150**	192	88	95	**132**	169
WHEAT	Grain	13.0-14.0	**13.3**	120	**166**	213	88	105	**146**	187
Selected Agricultural Origin – Australia										
CASSAVA	Fresh tubers	12.1-14.6	**13.4**	120	**167**	214	35	42	**58**	75
	Pellet	12.8-14.5	**14.2**	127	**177**	226	88	112	**156**	199
WHITE COTTON SEED		14.2-14.8	**14.5**	131	**181**	232	92	120	**167**	213
MILLETS										
- Unspecified	Grain	-	**11.3**	102	**141**	181	86	87	**121**	155
	Hay	-	**8.4**	76	**105**	134	85	64	**89**	114
- Foxtail	Grain	-	**13.9**	125	**174**	222	89	111	**155**	198
	Hay	-	**9.5**	86	**119**	152	87	74	**103**	132
- Common	Grain	-	**12.7**	114	**159**	203	90	103	**143**	183
	Hay	-								
- Pearl	Grain	-	**13.9**	125	174	222	90	113	**156**	200
	Hay	-								
KENAF	Yg Forage, dried	7.2-10.0	**8.6**	77	**108**	138	89	69	**96**	122
SUNN HEMP	Yg Forage, dried	-	**10.0**	90	**125**	160	89	80	**111**	142
LEUCAENA	Edible DM	7.8-10.0	**8.9**	80	**111**	142	90	72	**100**	128
SESBANIA	Edible DM	-	**10.8**	97	**135**	173	90	87	**122**	156
Selected Agricultural Origin – Imported										
CASSAVA	Pellet	12.8-14.5	**14.2**	127	**179**	226	88	112	**156**	199
Selected Industrial Origin – Australia										
FATS AND OILS		34.0-37.0	**35.5**	320	**444**	568	99	316	**439**	562
COMMERCIAL FOOD WASTES		?	?				?			

On the basis of this data, certain identified feedstuffs will frequently appear attractive in terms of overall ME cost, and can contribute to overall or sectional industry efficiency.

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5. GEOGRAPHIC, STRUCTURAL AND FINANCIAL IMPLICATIONS FOR THE CATTLE FEEDLOT INDUSTRY

5.1 INTRODUCTION

The contribution of an expanded use of existing energy dense feedstuffs, and of yet to be developed energy dense feedstuffs, can be assessed for both the existing intensive cattle feedlot industry, and for an expanded industry with ongoing market development and change.

In exploring the feedstuff options outlined in this study, three possible intensive cattle feeding situations are examined:

- the existing established feedlot industry,
- a future expanded feedlot industry, and
- an intensive live cattle export support feeding industry.

• The **Existing and Established Feedlot Industry**, produces a quality meat product for the export and/or domestic markets. It relies largely on grain as the principal ME source, and is located with appropriate slaughter, processing and packaging infrastructure nearby.

• A **Future Expanded Feedlot Industry**, would produce an improved quality meat product for the export and/or domestic markets. Located beyond where conventional grain sources are available, it would need to be based on yet to be established purpose-grown crops, agro-industrial by-products, imported feedstuffs, or combinations of these.

New feedstuff supply opportunities coupled with changing market emphasis will conceivably encourage future development of a feedlot industry in **northern Australia** when commercially attractive. This industry would supply the expanding Asian markets with product superior to that currently possible off northern grasslands. This future industry would contribute to the support of existing or yet to be established slaughter, processing, packaging and transport infrastructure.

Similarly, new feedstuff supply opportunities may substantially support localised feedlot industry components near sources of by-products, in **south eastern Australia**.

• An **Intensive Live Cattle Export Support Feeding Industry** in northern Australia would depot, hold, process and grow out cattle for live export.

This industry, presumably less capital intensive than the established industry, would accompany livestock trading operations and would likewise use purpose-grown crops, imported crops, or agro-industrial by-products, as the basic source of ME.

Importantly, with developing experience and operational expertise, this activity could be the precursor or catalyst to the northern feedlot industry in northern Western Australia, marketing improved quality meat into Asia.

5.2 ESTABLISHED INDUSTRY

Whilst subject to fluctuation, the indicative medium cost range for ME in much of the established industry is $1.20 to $1.30/100MJ (Table 3.1).

This study has identified feedstuffs whose ME costs are generally within this range, and whose judicious use could potentially advantage many participants and the industry overall. Some of the feedstuffs are already recognised by the industry for their value. Several are commonly used, but often at sub-optimal levels, whilst some are omitted altogether from feeding programmes due to possibly mistakenly perceived constraints.

It is for each feedlot site to evaluate feedstuffs within its own ration formulation principles, to achieve its own specific production and financial objectives.

The fats and oils, and locally produced WCS, are assessed as being able frequently to deliver ME to many established feedlot sites in the range $1.10 to $1.50/100MJ. Both WCS and the fats and oils have features imposing usage constraints; both are commonly selectively used, and both are frequently under utilised or not used at all.

AQIS has advised that a protocol is in place to import cassava pellets. Commercial interests have indicated that imported cassava could supply ME at the high end of this $1.10 to $1.50/100MJ range to feedlot sites, for example within 300km of port. Oil palm kernel meal and copra meal may also be able to be imported satisfactorily and used on an opportunity basis.

These feedstuffs offer much of the established industry immediate limited access to additional energy dense feedstuffs, either by their inclusion in rations, or by an increase in their existing inclusion rates when favourably costed. They do not alone offer a major alternative energy dense feedstuff with the capacity to have a significant impact on the existing industry. In combination, however, their impact may be significant.

Cassava was grown in Australia experimentally as a potential alternative fuel source when oil supplies were threatened in the 1970s. It was not evaluated as a feedstuff under industry conditions. If it could be grown commercially, it would be a substantial alternative energy dense feedstuff for the tropical, sub-tropical component of the feedlot industry. Importantly, it could ease the occasional feedgrain shortfall in regional southern Queensland and northern NSW.

It appears feasible for locally produced cassava to contribute up to 25% or 30% of total ration requirements at ME costs comparable with those of grain, and as such provide a viable alternative to part of the industry's dependence on grain.

Research is recommended to assess further the practicality and commercial feasibility of growing cassava in Australia for a feedstuff, and to address the perceived industry constraints limiting the greater use of WCS and fats and oils.

5.3 EXPANDED INDUSTRY

A northern Australian feedlot industry would conceivably produce an improved meat product for the growing Asian markets to Australia's immediate north. It would further expand the northern cattle industry's marketing spheres beyond the largely declining manufacturing meat markets and the currently rapidly growing live cattle export markets. It would offer considerable local value-adding opportunities embracing: additional farming activities; an expanded local meat export processing and packaging component; transport, and support industries as already demonstrated by the established industry in eastern Australia.

The industry has not developed to date, because of a general lack of suitable feedstuffs, despite early trial feedlot work in the Ord River Irrigation Area in the early 1970s.

In the short term, the possibility of utilising locally available WCS, molasses, and imported cassava may be sufficient to be the catalyst to encourage the industry's growth in northern Western Australia. The principal determinant of long-term industry viability will be feedstuff cost. This is dependent on supply and demand, and potentially subject to market fluctuations. It will remain so until the development of new industries such as, for example, substantial northern Western Australian cotton and sugar industries.

The expected expansion of the cotton industry in north Queensland, and the consequent increased production of WCS, may, with molasses and imported or locally grown cassava, underpin a viable expanded feedlot industry further supporting existing meat processing facilities.

Longer term, a northern industry requires a broader base of locally produced energy dense feedstuffs and this study has identified several tropical and sub-tropical crops warranting further research and development. These include cassava (processed tubers), the large and varied group of millets (grain, forage), the fibre crops kenaf, sunn hemp (forage), and the shrub legume leucaena and sesbania (forage).

These crops have the potential to contribute significantly, both individually and in combination, to a northern Australian feedlot industry's requirements for energy dense feedstuffs.

However, all these crops require industry oriented research and development to establish their commercial feasibility and viability. In particular, cost-effective technologies need to be developed to harvest, store, process and feed the various feedstuffs.

Additionally, existing and future feedlotting operations may be able to benefit from an expanded use of commercial food wastes, particularly in SE Australia. Insufficient data exist to ascertain the full opportunities for utilising waste as an alternative or enterprise based energy dense feedstuff. Research to quantify and qualify their significance appears warranted.

5.4 LIVE CATTLE EXPORT TRADE

The live cattle export trade continues to expand rapidly with increasing relative importance to the northern Australia cattle industry and the region as a whole.

Concurrent with this expanding trade has been the reduction in export meat works in northern Western Australia and the Northern Territory from ten in 1980 to two in 1996. The average age of turn off for cattle has fallen from 5 to 6 years to 1 to 2.5 years, reducing grazing pressures and permitting more sustainable range management in the absence of compensating increased breeder numbers.

Shipped cattle are fed on pasture and/or pellets after mustering, prior to shipment and whilst in transit. It is conceivable that further growth, and a greater need to ensure a continuity of livestock supply of assured quality, will encourage the industry to increase intensive feeding, with greater emphasis on ration quality and costs.

Currently, lucerne cubes delivered Darwin at $400/tonne equate to a ME cost of $5.50 to $6.00/100MJ. Clearly, the short term and long term requirements of this trade are similar to those for an expanded northern Australia feedlot industry (refer 5.3), necessitating the ready availability of reasonably costed suitable feedstuffs.

Significantly, with developing experience and operational expertise, the live cattle export activity could be the precursor or catalyst to the northern feedlot industry. This could be particularly so in northern Western Australia, where a feedlot industry might market improved quality meat into Asian markets in addition to live cattle.

6. CONCLUSIONS

This study has reviewed the alternative crop and by-product options capable of contributing as alternative energy dense feedstuffs to the Australian cattle feedlot industry.

The cattle feedlot industry has a geographic spread, scale, and range of sophistication that enables only a general overview. There are also limitations in evaluating a feedstuff on a single nutrient component, such as metabolisable energy content, rather than its full nutrient profile.

The industry was segmented for this study into the existing and established feedlot industry, a future expanded feedlot industry, and an intensive live cattle export support feeding industry.

An extensive review of feedstuffs identified a short list of crops and by-products for closer examination. These comprised feedstuffs of Australian and imported agricultural origin, and Australian industrial origin, from which some 10 have been selected for particular attention. The basis of this selection was that feedstuff ME values equalled or exceeded 10MJ/kg, and expected cost was comparable with current feedstuff sources which are principally the cereal grains.

Feedstuffs have been identified which in combination with established nutrient sources, or with other identified feedstuffs, are capable of contributing to increased efficiency and stability in the existing industry. Additionally, they may underpin industry expansion away from the current predominant grain producing areas to new locations.

There appears to be no new product or by-product capable of significantly hedging the Australian industry against future feedstuff cost fluctuations. Such cost fluctuations are predominantly determined by global feedstuff supply and demand interactions.

However, there are discernible advantages and opportunities offered by the feedstuffs studied.

The by-products fats and oils, and white cotton seed (WCS) are frequently under utilised, in some cases due to perceived constraints, by much of the established industry. Both are widely used internationally in intensive production programs, and there is much knowledge on their nutritional properties, supporting their increased use.

As the cotton industry expands in northern Australia there will be an increasing availability of WCS. WCS is a potentially valuable feedstuff to underpin an expanded feedlot industry or intensive live cattle export trade, possibly in conjunction with an expanding sugar industry and associated by-products. Research is suggested to clarify maximum possible inclusion rates and possible effect on meat quality, in particular for WCS.

AQIS has confirmed that protocols have recently been established enabling the importation of cassava pellets from Thailand. Initial enquiries suggest that such imports might be at costs which make them competitive ME sources for much of industry, particularly an expanded northern Australia industry. Additionally, and longer term, cassava could possibly be grown locally as an animal feedstuff. Cassava's contribution would be greatest in the tropical and sub tropical areas and may alleviate the periodic grain shortages experienced in southern Queensland. It could also underpin an expansion of intensive cattle feeding in northern Australia. Research is suggested to further explore and, if appropriate, develop the possibility of growing cassava locally as an animal feedstuff.

The millets as a group offer potential as ME sources in the tropics and sub-tropics. They can be grown in conjunction with other prime feedstuffs, as purpose-grown grain or as early harvested forage crops. In general they have been 'under researched' and 'under developed' internationally. The many species and varieties available offer sufficient promise to suggest that with further investigation, these could contribute to an expanded northern Australian industry.

Similarly, the fibre crops kenaf and sunn hemp together with the shrub legumes leucaena and sesbania appear potentially valuable ME sources in northern Australia when grown as forages and harvested while immature. There is however inadequate information in Australia to evaluate their potential contribution meaningfully. Research with a strong feedlot industry focus and commercial basis is suggested to assess their possible contribution further, paying attention to their cultural, harvesting, processing and storage practices, and nutrient values.

Crop and pasture research in northern Australia has been largely agronomic and oriented to the grazing or fibre industries, rather than to the feedlot industry. The result is that there is little information available regarding the potential of northern Australian crops and forage plants as feedstuffs for the feedlot industry.

Finally, there appear to be large quantities of commercial food wastes available, principally in urban areas. However, very little is known about the quantities available and their feeding quality. It is unlikely they will contribute to the greater industry, but they may support or part-support localised industries.

SWOT analyses and conclusions for the individual selected feedstuffs are presented in Section 4.3. Detailed assessments of the selected feedstuffs are given in Appendix 2, and recommendations for further research and development are outlined in Section 7.

7. RECOMMENDATIONS FOR FURTHER RESEARCH AND DEVELOPMENT

7.1 IDENTIFICATION

The constraints, limiting factors influencing the constraints and areas for further research have been identified for each selected potential feedstuff. These are discussed below.

7.1.1 Fats and Oils

The two constraints to greater use in the industry are considered to be lack of appreciation of the feedstuff's worth and comparative value, and uncertainty as to maximum inclusion rates.

These aspects are well covered in the literature and further research is considered unwarranted.

7.1.2 White Cotton Seed

The industry generally appreciates the nutritional contribution of WCS. The constraints to broader use within the industry are the perception that it can affect carcase quality, and that the maximum advisable ration inclusion rates are in the order of 8% to 15%. There is also the consideration that the product may be chemically contaminated.

Research is suggested as follows:

- Clarify the effect of WCS on carcase quality under a range of feeding regimes.
- Further examine the literature regarding maximum inclusion rates and conduct feeding trials with WCS at a range of inclusion rates under different feeding regimes.
- Assess and report on the possibility of chemical contamination arising from the feeding of WCS.

7.1.3 Cassava, imports

No further research is warranted. Commercial initiatives are required to examine and test the protocols for importation, and to determine their commercial practicality. Commercial initiatives may also be warranted to examine the possibility of joint venture operations in South Pacific countries to produce, process and export cassava chips to Australia.

7.1.4 Cassava, local crop

The last substantial commercial assessment in Australia was to evaluate the crop as a potential alternative fuel energy source. There appears to have been no full evaluation of the crop as a potential animal feedstuff.

Research is suggested as follows:

- A desktop feasibility study to assess the financial practicality of growing cassava in Australia as an energy dense feedstuff for the intensive cattle industries.
- If the results of the feasibility study are promising, a pilot operation to further assess the viability of a commercial cassava industry at a range of sites, and to test for suitable varieties.

7.1.5 Millets

The millets include species which appear to be capable of significant grain production in northern Australia where current cereal grains perform poorly.

Research is suggested as follows:

- Examine in depth the available knowledge to ascertain fully the possible contribution that millets can make as energy dense feedstuffs. The study should particularly examine their potential in tropical and sub-tropical areas.
- If this study indicates that they have the potential to aid the intensive cattle feeding industries, field test production systems including harvesting, storage, and processing in a manner able to indicate potential commercial viability as a crop and as a feedstuff should be undertaken.

7.1.6 Forage Crops, harvested whilst immature

Basically, there is extremely limited knowledge available for the commercial evaluation of the potential of the suggested fibre crops (kenaf, sunn hemp), and the shrub legumes (leucaena, sesbania), grown as forage crops and early harvested, as an energy dense feedstuff in tropical and sub-tropical Australia. There are indications, suggestions, stated possibilities, ideas, but few facts.

Research is suggested:

- Short list the possibilities and field test with the objective of determining yields, feedstuff nutritive values, cultural, harvesting, processing and storage practices of commercial application.

The suggested research should have an industry focus, specifically directed towards the production of forage for use as a feedstuff in the feedlot industry, and be capable of commercial assessment and evaluation.

7.1.7 Commercial Food Wastes

Very little is known of this resource which may support or part support localised industry.

The following research is suggested:

- Establish a data base which qualifies and quantifies food industry wastes in relation to location, current disposal practices, production trends and other relevant factors.

Initially this should be for one State, presumably NSW, where some initial work has been done.

It is the finding of this study that appropriate research of the above products is likely to lead to their further availability, and/or use of a feedstuff, and the refinement and development of alternative energy sources, capable of contributing to increased efficiency in the feedlot industry and of underpinning an expansion of the industry into new areas.

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ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance provided in the compilation of this study by a large number of individuals. In particular, we extend our thanks to the following.

ALFA, Sydney
Bainish L., University of Southern Queensland, Gatton
Bell A.K., NSW Agriculture, Tamworth
Branson R., Qubator Pty Ltd, Sydney
Cordingley W., AMLC, Sydney
Dale A.B., NSW Agriculture, Gunnedah
David Kidd Grain Trading Pty Ltd, Willow Tree
Grigg J., 'Ethonga', Wamuram
Haire R., Queensland Cotton Ltd, Dalby
Hedditch M.J., Rice Growers Association of Australia, Leeton
Hume R.H., CSIRO Division of Food Science & Technology, Cannon Hill
Hutton K., Rice Growers Co-operative Ltd, Leeton
Kneipp J.F., NSW Agriculture, Gunnedah
Little S., University of Western Sydney, Richmond
Mataranka Grains Pty Ltd, Dayboro
McDonald W.J., NSW Agriculture, Tamworth
Montgomery D., Dunavat Enterprises Pty Ltd, Moree
Moore E., MRC, Sydney
Mulders C., MRC, Sydney
Navett S., QDPI Maroochy Research Centre, Nambour
Pankhurst G., Tipperary Indonesia, Jabung
Reid D., Wilala Agricultural Pty Ltd, St Leonards
Roese G.J., NSW Agriculture, Tamworth
Smith L., QDPI Centre for Food Technology, Brisbane
Smith T., Gardner Smith Pty Ltd, North Sydney
Swete Kelly D., QDDI Maroochy Horticultural Research Station, Nambour
Sykes J., NSW Agriculture, Dubbo
Thompson J.A., NSW Agriculture, Deniliquin
Wearing J., Wearing Carrying Company, Myrtletown, Brisbane
van den Brock, B., Waste Service NSW, Chatswood

APPENDIX 1
Energy Dense Feedstuffs

A1.1 Crop, Pasture and By-product Feedstuffs

Potential feedstuffs are grouped and listed in Appendix Table 1, with indicative ME values and estimates of likely costs where available. The estimation of likely costs presents particular difficulties where the potential crop has not been grown commercially in Australia or where the production system needs to be radically changed to produce a feedstuff suitable for feedlot use. Costs and prices can also be expected to vary widely depending on seasonal conditions and locations.

Appendix Table 1 List of potential energy dense feedstuffs
(see following)

Appendix Table 1 List of potential energy dense feedstuffs

FEEDSTUFF *Botanical Name*	Description	Indicative Cost ($/tonne)	% Dry Matter	Dry Basis (100% Dry Matter) Metabolisable Energy (MJ/kg)	(Mcal/kg)	Crude Protein	Opportunity Cost ($/tonne)	($/100MJ of ME)	Special Qualities (a)	Category (b)
Cereals – Grains, Hay and Silages										
BARLEY *Hordeum vulgare*	All analyses, grain	$150	88	13.0	3.1	13.2	$171	$1.31		P
BARLEY *Hordeum vulgare*	Grain screenings		89	13.1	3.1	13.0				P
BARLEY *Hordeum vulgare*	Hay, sun cured	$110	87	8.5	2.0	8.7	$126	$1.49		Ue
BARLEY *Hordeum vulgare*	Silage		31	7.7	1.8	10.3				Ue
BARLEY *Hordeum vulgare*	Straw	$60	91	6.1	1.5	4.3	$66	$1.09		Ue
MAIZE, DENT YELLOW *Zea mays, indentata*	All analyses, grain	$200	88	13.7	3.4	11.2	$227	$1.66		P
MAIZE, DENT YELLOW *Zea mays, indentata*	Grain, high moisture		77	15.3	3.7	10.6				P
MAIZE, DENT YELLOW *Zea mays, indentata*	Straw	$60	85	7.0	1.7	5.0	$71	$1.01		Ue
MAIZE, DENT YELLOW *Zea mays, indentata*	Silage	$40	37	10.3	3.0	8.0	$108	$1.05		P
MAIZE, POPCORN *Zea mays, everta*	Grain	$400	90	14.6	3.5	12.8	$444	$3.04		Um
MAIZE, SWEETCORN *Zea mays, saccharata*	Grain		91	14.9	3.6	12.4				Um
MILLET, FOXTAIL *Setaria italica*	Grain		89	13.9	3.3	13.1				P
MILLET, FOXTAIL *Setaria italica*	Hay		87	9.5	2.3	8.6				Ue
MILLET, PEARL *Pennisetum glaucum*	Grain		90	13.9	3.3	14.3				P
MILLET, PEARL *Pennisetum glaucum*	Hay		87	9.5	2.3	8.6				Ue
MILLET, UNSPECIFIED *Setaria spp*	Grain		86	11.3	2.7	12.1				P

FEEDSTUFF *Botanical Name*	Description	Indicative Cost ($/tonne)	% Dry Matter	Dry Basis (100% Dry Matter) Metabolisable Energy (MJ/kg)	Metabolisable Energy (Mcal/kg)	Crude Protein	Opportunity Cost ($/tonne)	Opportunity Cost ($/100MJ of ME)	Special Qualities (a)	Category (b)
MILLET, UNSPECIFIED *Setaria spp*	Hay		85	8.4	2.0	12.5				Ue
OATS *Avena sativa*	All analyses, grain	$100	89	12.3	2.9	13.3	$112	$0.91		P
OATS *Avena sativa*	Hay	$110	88	11.5	2.8	8.0	$125	$1.09		Us
OATS *Avena sativa*	Straw		85	7.0	1.7	4.0				Ue
RICE *Oryza sativa*	Grain (rough rice, paddy rice)		89	12.3	2.9	8.4				Um
RICE *Oryza sativa*	Hulls		92	1.8	0.4	3.0				Ue
RICE *Oryza sativa*	Straw	$60	91	6.2	1.5	4.0	$66	$1.06		Ue
RYE *Secale cereale*	All analyses, grain		87	12.4	3.0	13.8				Us
RYE *Secale cereale*	For silage/hay		24	10.5	2.5	16.0				Uc
RYE *Secale cereale*	Straw	$60	90	4.7	1.1	3.0	$67	$1.42		Ue
SORGHUM *Sorghum bicolor*	Grain, 8-10% protein	$150	88	12.0	2.9	10.0	$170	$1.42		P
SORGHUM *Sorghum bicolor*	Silage		30	9.1	2.2	8.0				M
SORGHUM *Sorghum bicolor*	Straw	$60	88	8.2	2.0	5.0	$68	$0.84		Ue
SORGHUM SUDANGRASS *Sorghum bicolor, sudanese*	Grain		92	7.6	1.8	15.4				Ue
TRITICALE *Triticale hexaploide*	Grain	$100	89	13.2	3.2	17.3	$112	$0.85		P
WHEAT *Triticum aestivum*	All analyses, grain	$200	88	13.3	3.2	14.7	$227	$1.71		P
WHEAT *Triticum aestivum*	Straw	$60	85	7.0	1.7	4.0	$71	$1.01		Ue

FEEDSTUFF *Botanical Name*	Description	Indicative Cost ($/tonne)	% Dry Matter	Dry Basis (100% Dry Matter) Metabolisable Energy (MJ/kg)	(Mcal/kg)	Crude Protein	Opportunity Cost ($/tonne)	($/100MJ of ME)	Special Qualities (a)	Category (b)
WHEAT, DURUM *Triticum durum*	Grain		88	14.2	3.4	15.7				Uc
Root Crops – Tubers, Tops										
BEET, COMMON RED *Beta vulgaris, crassa*	Roots, fresh		13	12.4	3.0	12.5				Us
BEET, FODDER *Beta vulgaris*	Crop		18	12.5	3.0	13.0				Us
BEET, SUGAR *Beta vulgaris, altissima*	Roots, fresh	$200	20	13.7	3.3	6.8	$1,000	$7.30		Uc
CASSAVA *Manihot spp*	Tubers, dehydrated, pellets	$147.50	88	14.2	3.4	2.6	$167.60	$1.18		P
CASSAVA *Manihot spp*	Tubers, fresh		35	13.4	3.2	3.6				P
DASHEEN (TARO) *Colocasia esculenta*	Tubers, fresh		28	13.6	3.2	5.4				Us
KOHLRABI *Brassoca p;eracea*	Roots		13	10.8	2.6	15.4				Us
POTATO *Solanum tuberosum*	Tubers, fresh	$300	23	12.3	2.9	9.5	$1,304	$10.60		Um
POTATO *Solanum tuberosum*	Tubers, silage		25	12.4	3.0	7.6				Us
SWEET POTATO *Ipomoea batatas*	Tubers, fresh		33	12.9	3.1	5.0				Us
TURNIP *Brassica rapa, rapa*	Roots, fresh	$700	9	13.9	3.3	13.1	$7,778	$55.82		Us
TURNIP SWEDE *Brassica napus*	Roots, fresh	$330	12	12.8	3.1	10.8	$2,750	$21.48		Us
Oilseed Crops										
FLAX, COMMON *Linum usitatissimum*	Grain		90	19.4	4.6	26.0				Us
FLAX, COMMON *Linum usitatissimum*	Grain, screenings		91	9.5	2.3	18.2				Us

FEEDSTUFF *Botanical Name*	Description	Indicative Cost ($/tonne)	% Dry Matter	Dry Basis (100% Dry Matter)					Special Qualities (a)	Category (b)
				Metabolisable Energy (MJ/kg)	Metabolisable Energy (Mcal/kg)	Crude Protein	Opportunity Cost ($/tonne)	Opportunity Cost ($/100MJ of ME)		
OLIVE *Olea europaea*	Fruit without pits, dehydrated		93	8.3	2.0	11.6				Uc
RAPE (CANOLA) *Brassica napus*	Fresh, silage/hay		11	11.3	2.7	23.5			Cp	Us
RAPE (CANOLA) *Brassica napus*	Grain	$300	83	12.0	2.9	16.0	$362	$3.01		Us
SAFFLOWER *Carthamus tinctorius*	Grain		93	11.8	2.8	16.0				Us
SOYBEAN *Glycine max*	Grain	$350	92	15.2	3.6	41.7	$380	$2.50	Cp	Um
SOYBEAN *Glycine max*	Hay, sun-cured, midbloom		94	8.0	1.9	17.8				Ue
SOYBEAN *Glycine max*	Hulls (grain coats)		91	9.7	2.3	12.1				Us
SOYBEAN *Glycine max*	Silage		27	8.3	2.0	17.3				Us
SOYBEAN *Glycine max*	Straw		88	6.4	1.5	5.2				Ue
SUNFLOWER *Helianthus spp*	Grain	$340	94	13.6	3.3	22.2	$362	$2.66	Cp	Um
Pulses										
BEAN, BUTTER *Phaseolus vulgaris*	Grain		86	12.6	3.0	26.5			Cp	Uc
BEAN, KIDNEY *Phaseolus vulgaris*	Grain		89	13.5	3.2	24.7			Cp	Uc
BEAN, LIMA *Phaseolus limensis*	Grain		90	14.3	3.4	23.1			Cp	Uc
BEAN, MUNG *Phaseolus aureus*	Grain		90	13.9	3.3	26.6			Cp	Uc
BEAN, NAVY *Phaseolus vulgaris*	Grain		89	14.1	3.4	25.6			Cp	Uc
BEAN, PINTO *Phaseolus vulgaris*	Grain		90	13.3	3.2	25.1			Cp	Uc

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CHICKPEA *Cicer arietinum*	Grain	$210	89	13.8	3.5	21.4	$236	$1.71	Cp	P
COWPEA, COMMON *Vigna sinensis*	Grain		89	13.6	3.3	26.0			Cp	P
COWPEA, COMMON *Vigna sinensis*	Hay, sun-cured		90	9.0	2.1	19.4				Ue
COWPEA, COMMON *Vigna sinensis*	Pods with grain, dehydrated		92	12.3	3.0	23.5			Cp	Us
FABA BEAN *Vicia faba*	Grain	$250	88	13.1	3.1	29.0	$284	$2.16	Cp	Um
LABLAB *Lablab purpureus*	Grain		90	12.5	3.0	25.0			Cp	Uc
LENTIL, COMMON *Lens culinaris*	Grain		88	13.7	3.3	27.6			Cp	Uc
LUPINS, SWEET *Lupinus spp*	Grain		85	13.5	3.2	30.0			Cp	Us
LUPINS, SWEET *Lupinus spp*	Hay		15	10.0	2.4	17.0				Ue
PEANUT *Arachis hypogaea*	Hay, sun-cured		91	8.3	2.0	10.8				Ue
PEANUT *Arachis hypogaea*	Hulls (pods)		91	3.4	0.8	7.8				Ue
VETCH *Vicia spp*	Grain		91	12.1	2.9	32.6			Cp	Us
VETCH *Vicia spp*	Hay, sun-cured		89	8.6	2.1	20.8			Cp	Ue
Fruit & Vegetables										
ALMOND *Prunus amygdatuss*	Hulls		90	11.8	2.8	4.5				Us
APPLE *Malus spp*	Fruit, fresh		18	12.3	3.0	2.8				Uc
ARTICHOKE, JERUSALEM *Helianthus tuberosus*	Tubers, fresh		20	13.2	3.2	9.7				Us

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BANANA *Musa spp*	Fresh fruit		57	9.6	2.3	5.2				Um
BROCCOLI *Brassica olerancea*	Purple sprouting	$1,500	12	11.1	2.7	15.8	$12,500	$112.74		Um
CABBAGE *Brassica oleracee*	Drumhead		11	10.4	2.5	23.6			Cp	Um
CABBAGE *Brassica oleracea*	Open leaved		15	10.8	2.6	16.0				Um
CACAO (COCOA) *Theobroma cacao*	Grain coats (shells)		92	8.7	2.1	15.7				Us
CARROT *Daucus spp*	Roots, fresh	$200	11	13.8	3.3	10.0	$1,818	$13.17		Uc
GRAMA *Bouteloua spp*	Fresh, early vegetative		41	9.1	2.2	13.1				Ue
GRAMA *Bouteloua spp*	Fresh, mature		63	8.3	2.0	6.5				Ue
PARSNIP, GARDEN *Pastinace sativa*	Roots, fresh		17	13.4	3.2	10.0				Uc
PEA *Pisum spp*	Chop residues		18	10.9	2.6	14.0				Us
PEA *Pisum spp*	Grain		89	13.2	3.2	25.3			Cp	Us
PEA *Pisum spp*	Grain coats (pea hulls)		90	10.3	2.5	12.1				Us
PEA *Pisum spp*	Straw		85	7.0	1.7	8.0				Ue
PEA *Pisum spp*	Vines without grain, silage		25	8.6	2.1	13.1				Ue
PEA FIELD *Pisum sativum, arvense*	Grain		91	13.6	3.3	25.4			Cp	Um
PINEAPPLE *Ananas comosus*	Hay, aerial part without fruit		89	9.2	2.2	7.8				Us
PUMPKIN, *Cucurbita pepo*	Fruit, fresh	$180	9	14.4	3.5	17.3	$2,000	$13.86		Uc

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TOMATO *Lycopersicon esculentum*	Fruit, fresh	$100	6	13.1	3.1	16.4	$1,667	$12.77		Uc
Pastures & Forages										
BLADDER SALTBUSH *Atriplex*			36	9.5	2.3	11.8				Ue
BUTTER BUSH *Pittosporum phylliraeoides*	Leaf and stem		96	10.0	2.4	8.6				Ue
CLOVER, WHITE *Trifolium repens*	Hay, early vegetative	$120	20	10.0	2.4	27.2	$133	$1.33	Cp	P
LEUCAENA *Leucaena leucocephala*	Green chop		90	8.9	2.1	21.5			Cp	P
LUCERNE *Medicago sativa*	Hay, sun-cured, midbloom	$150	90	8.8	2.1	15.0	$167	$1.90		P
LUCERNE *Medicago sativa*	Silage wilted, midbloom	$45	38	8.8	2.1	15.0	$118	$1.35		P
MIMOSA *Mimosaceae*	All		37	10.4	2.5	19.1				Us
RYEGRASS *Lolium multiflorum*	Hay		85	8.0	1.9	6.0				Ue
RYEGRASS/WHITE CLOVER *Lolium multiflorum*	Spring - mixed, hay		15	11.2	2.7	20.0			Cp	P
SALTBUSH, NUTTALL *Atriplex nuttallii*	Browse, fresh, stem-cured		55	5.4	1.3	7.0				Ue
TEMPERATE PASTURE SPECIES *various spp*	Fresh vegetative stage		19	10.3	2.5	27.0			Cp	P
TROPICAL PASTURE GRASSES *various spp*	Hay (young; 2 weeks)		90	10.0	2.4	18.0				P
TROPICAL PASTURE LEGUMES *various spp*	Hay (6 weeks)		90	7.5	1.8	4.0				Ue
Sugarcane										
SUGARCANE *Saccharum officinarum*	Molasses	$90	77	11.0	2.6	4.0	$118	$1.07		P

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Fibre Crops										
HEMP *Cannabis sativa*	Grain		90	17.5	4.2	20.0				Us
KENAF *Hibiscus cannabinus*	Edible dry matter		89	8.6	2.1	15.5				P
SESBANIA *Sesbania sesban*	Edible dry matter		90	10.8	2.6	24.0			Cp	P
Aquatic Plants										
ALGAE, GREEN *Scenedesmus quadricuada*	Fan dried		93	8.4	2.0	50.0				Ue
KELP (SEAWEED) *Laminariales (order), Fucales (order)*	Whole, dehydrated		91	4.0	1.0	7.1				Ue
Industrial By-products										
APPLE *Malus spp*	Pomace, dehydrated		89	10.7	2.6	5.0				Us
APPLE *Malus spp*	Pomace, wet		23	11.7	2.8	5.6				Us
ASPARAGUS, GARDEN *Asparagus officinalis*	Stem butts, meal		91	7.0	1.7	15.6				Us
BAKERY	Waste, dehydrated (dried bakery product)		91	14.5	3.5	11.1				Us
BANANA *Musa spp*	Fruit, dehydrated		86	12.5	3.0	4.1				Um
BANANA *Musa spp*	Peelings, dehydrated		91	10.8	2.6	9.4				Us
BARLEY *Hordeum vulgare*	Malt sprouts, dehydrated		93	11.3	2.7	24.6			Cp	Us
BEAN, BROAD *Phaseolus*	Pod meal		90	10.4	2.5	16.7				Us
BISCUIT & CAKE MIX	Waste		95	12.5	3.0	7.4				Us

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BLOODMEAL			90	13.2	3.2	88.0			Cp	Uc
BREAD, WHEAT *Triticum aestivum*	Dehydrated		95	11.2	2.7	13.0				Us
BREAKFAST CEREAL	Waste		92	12.5	3.0	11.6				Us
BREWERS GRAINS *Triticum aestivum*	Grain, dehydrated		92	10.1	2.4	29.6			Cp	Us
BREWERS GRAINS *Triticum aestivum*	Grain, wet		22	11.6	2.8	26.4				Us
BUTTERMILK	Powder, protein concentrate		93	13.2	3.2	34.0				Uc
CARROT *Daucus spp*	Roots, dehydrated		89	13.0	3.1	10.3				Us
CASSAVA *Manihot spp*	Tapioca flour		90	15.0	3.6	2.0				P
CASSAVA *Manihot spp*	Tubers, fresh		37	12.7	3.0	3.6				P
CITRUS *Citrus spp*	Pulp, silage		21	13.3	3.2	7.3				Us
CITRUS *Citrus spp*	Pulp, wet		18	12.6	3.0	6.6				Us
CITRUS *Citrus spp*	Syrup (molasses)		67	11.8	3.8	8.5				Us
COPRA *Cocos nucifera*	Meal, mech extract	$215	90	14.0	3.4	23.0	$239	$1.71	Cp	P
COTTON SEED *Gossypium spp*	Hulls		91	6.4	1.5	4.1				Ue
COTTON SEED *Gossypium spp*	Meal, solvent	$220	91	11.7	2.8	37.0	$242	$2.06	Cp	Uc
COTTON SEED *Gossypium spp*	Whole white seed	$160	92	14.5	3.5	23.0	$174	$1.20	Cp	P

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FATS & OILS	Animal	$400	99	37.0	8.8	0.0	$404	$1.09		P
FATS & OILS	Vegetable	$400	99	34.0	8.1	0.0	$404	$1.19		P
FISH	Meal		92	11.8	2.8	68.0			Cp	Uc
GRAPES *Vitis spp*	Fruit (raisins)		87	10.0	2.4	7.4				Ue
GRAPES *Vitis spp*	Pomace, wet (marc)		37	7.3	1.7	13.8				Ue
HOPS *Humulus lupulus*	Leaves and vine, dried		89	8.2	2.0	14.0				Ue
LINSEED *Linum usitatissimum*	Meal		90	12.9	3.1	35.4			Cp	Us
MACADAMIA NUT *Macadamia integrifolia*	Waste		98	16.5	4.0	10.1				Us
MAIZE, DENT YELLOW *Zea mays, indentata*	Gluten, meal		91	13.0	3.1	36.7			Cp	Us
MAIZE, DENT YELLOW *Zea mays, indentata*	Bran		89	12.4	3.0	9.4				Us
MAIZE, DENT YELLOW *Zea mays, indentata*	Oil		99	34.0	8.2	0.0				Us
MAIZE, DENT YELLOW *Zea mays, indentata*	Starch		90	14.3	3.4	0.6				Us
MAIZE, SWEET *Zea mays, saccharata*	Cannery residue, fresh		77	10.8	2.6	8.8				Us
MAIZOFERM			39	15.6	3.7	49.3			Cp	Us
MEATMEAL	Pure meat		90	16.0	3.8	81.0			Cp	Um
MILK	Skimmed, dried		94	15.1	3.6	35.5			Cp	Uc

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MILK	Whole, dried		95	20.2	4.8	26.0				Uc
OATS *Avena sativa*	Cereal by-product		91	15.8	3.7	15.3				Us
OIL PALM KERNEL *Palmae*	Meal, mech extracted	$140	90	12.5	3.0	15.0	$156	$1.24		P
OLIVE *Olea europaea*	Meal		90	12.7	3.0	7.1				Us
PEA *Pisum spp*	Split grain by-product (pea meal)		90	12.0	2.9	19.7				Us
PEANUT *Arachis hypogaea*	Meal, mech extracted		93	12.6	3.0	52.0			Cp	Us
PEANUT *Arachis hypogaea*	Hulls		91	3.4	0.8	7.5				Ue
PEAR *Pyrus spp*	Pomace, dehydrated		90	11.2	2.7	5.5				Us
PEAR *Pyrus spp*	Pomace, wet		17	10.0	2.6	4.2				Us
PINEAPPLE *Ananas comosus*	Hay, aerial part without fruit		89	9.2	2.2	7.8				Us
PINEAPPLE *Ananas comosus*	Cannery by-product		13.6	10.8	2.7	5.4				Us
POPPY SEED *Papaven somniferum*	Meal		90	11.3	2.7	40.8			Cp	Us
POTATO *Solanum tuberosum*	Cannery residue, dehydrated		89	13.5	3.2	8.4				Us
POTATO *Solanum tuberosum*	Cannery residue, wet		12	12.0	2.9	8.5				Us
POTATO *Solanum tuberosum*	Fresh		23	12.3	2.9	9.5				Uc
POTATO *Solanum tuberosum*	Tubers, dehydrated		91	12.7	3.0	8.9				Us
POTATO, SWEET *Ipomoea batatas*	Cannery residue, dehydrated		90	12.1	2.9	2.8				Us

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				Metabolisable Energy (MJ/kg)	Metabolisable Energy (Mcal/kg)	Crude Protein	Opportunity Cost ($/tonne)	Opportunity Cost ($/100MJ of ME)		
POTATO, SWEET *Ipomoea batatas*	Tubers, dehydrated		89	12.6	3.1	7.2				Us
RAPE (CANOLA) *Brassica napus*	Grain, meal, mech extracted		92	11.5	2.8	38.7			Cp	Us
RICE *Oryza sativa*	Bran with germs		91	10.0	2.4	14.3				Um
RICE *Oryza sativa*	Polishings		90	14.6	3.5	13.3				Um
RICE *Oryza sativa*	Rice, brown		88	14.5	3.5	8.4				Um
RICE *Oryza sativa*	Rice, polished		89	15.0	3.6	7.9				Um
RYE *Secale cereale*	Bran		91	10.8	2.6	17.5				Us
RYE *Secale cereale*	Flour		89	13.8	3.3	11.7				Us
SAFFLOWER *Carthamus tinctorius*	Meal, mech extracted		91	9.1	2.2	22.0			Cp	Us
SAFFLOWER *Carthamus tinctorius*	Meal, solvent extracted		92	9.0	2.2	25.0			Cp	Us
SESAME *Sesamum indicum*	Meal, mech extracted		93	11.6	2.8	49.0			Cp	Us
SOYBEAN *Glycine max*	Grain, meal, mech extracted		90	12.8	3.1	47.7			Cp	Um
SOYBEAN *Glycine max*	Meal, solvent extracted		90	13.2	3.2	55.1			Cp	Um
SOYBEAN *Glycine max*	Mill feed		90	10.7	2.6	14.1				Us
SUNFLOWER, COMMON *Helianthus annuus*	Meal, mech extracted		93	11.2	2.7	44.6			Cp	Us
SUNFLOWER, COMMON *Helianthus annuus*	Meal, solvent extracted		93	9.9	2.4	49.8			Cp	Ue
TOMATO *Lycopersicon esculentum*	Pomace, dehydrated		92	10.3	2.5	22.9			Cp	Us

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TOMATO *Lycopersicon esculentum*	Pomace, wet		25	9.5	2.3	21.5			Cp	Us
WHEAT *Triticum aestivum*	Bran		89	11.3	2.7	17.5				Us
WHEAT *Triticum aestivum*	Gluten		90	14.7	3.5	70.3			Cp	Us
WHEAT *Triticum aestivum*	Pollard		85	12.2	2.9	18.0				Us
WHEY *Bos taurus*	Dried		93	14.5	3.5	9.6				Us
WHEY *Bos taurus*	Whole		7	14.5	3.5	10.6				Us
YEAST, BREWERS *Saccharomyces*	Dehydrated		93	12.0	2.9	46.9			Cp	Um

SOURCES OF DATA:

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AFIC (1987b)
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Morrison (1959)
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National Research Council (1996)
NSW Agriculture (1996a)
NSW Agriculture (1996b)
NSW Agriculture (1996c)

FOOTNOTES:

(a) **Special Qualities**

CP .... can significantly contribute to the ration crude protein component.
Min .... can significantly contribute to the ration mineral component.
Phy .... can significantly contribute to the ration physical qualities.

(b) **Category**

P .... promising, ME exceeds 10 MJ/kg.
M .... marginal, ME between 8.5 and 10 MJ/kg, but has special qualities.
Uc .... generally limited potential, due to high cost of production.
Us .... generally limited potential, due to supply considerations (may be specific opportunities).
Ue .... generally limited potential, due to low ME.
Um .... generally limited potential, due to high value market alternatives.

A1.2 Discussion

General comments are warranted on several of the Appendix Table 1 feedstuff groups, particularly the root crops, pastures and forages, and the fibre crops.

All **root crops** have the following common characteristics:

- Offer high energy values.
- Are grown primarily for human consumption and can be expected to be non-competitive with current feedlot industry feedstuffs on a cost basis.
- May contain chemical residues due to contamination of adhering soil by regular use of insecticide.

The **pastures and forages** include a wide range of temperate and tropical pasture grasses and legume species having similar feeding value characteristics. The young growth of tropical grasses has a high digestibility, and hence a relatively high ME, which rapidly declines with age. These changes are illustrated in Appendix Table 2 (Partridge and Miller 1991).

Appendix Table 2 Changes in digestibility and ME of tropical pasture grasses and tropical pasture legumes over time

Component	Grasses		Legumes	
	Digestibility %	Estimated ME (MJ/kg)	Digestibility %	Estimated ME (MJ/kg)
Leaf, young green	68	9.4	72	10.3
Leaf, old green	55	7.5	60	8.6
Leaf, dry	30	3.9	45	6.4
Stem, old	25	3.2	40	5.6

Note: The ME values have been estimated from DM digestibility (DMD) applying the formula ME = 0.8 x Digestible Energy (DE)

For tropical pasture grasses - DE = (18.0 X DMD) – 0.48
For tropical pasture legumes DE = (18.4 X DMD) – 0.34

Clearly, with tropical grasses, only very young growth (four to six weeks old) produces a feedstuff acceptable to the feedlot industry. Costing is difficult as these pastures are normally only grazed. Therefore, a value of $150/tonne of hay has been assumed, this being an indicative price for lucerne hay.

Tropical pasture legumes include:

- Herbaceous legumes (including *Aeschynomene americana, Aeschynomene falcata, Arachis glabrata, Arachis pintoi, Chaemecrista rotundifolia*, and various species of *Stylosanthes*),
- Twining/viny legumes (including *Centrosema spp., Clitoria ternatea, Desmodium spp., Macroptilium atropurpureum, Neonotonia wightii, Vigna parkeri, Calopogonium mucunoides, Canavalia ensiformis, Flemingia macrophylla*), and
- Shrubby legumes (including *Desmanthus virgatus, Leucaena leucocephala*, and *Sesbania sesban*).

Some of the twining species, such as *Calopogonium, Canavalia* and *Flemingia* are grown as cover crops or for green manure, and are generally unpalatable to cattle.

The leaves of tropical legumes have digestibility values which decline rapidly from about 70% when young, to 40% to 45% when mature (Appendix Table 2). Very young (two week old) leaf material has the highest digestibility. Stems are generally less digestible, ranging from 30% to 50%, thus excluding these plants from the 'energy dense' range unless very young (less than two months). Leaf crude protein usually ranges 12.5% to 25.0%, with stems closer to 4% to 8%. The stem content of the herbaceous legumes increases with age, leading to lower quality.

Many tropical legumes contain toxins, tannins, oestrogens, saponins, or other anti-quality characteristics.

However, the shrub legumes may offer ME source possibilities, particularly *Leucaena* and *Sesbania*.

There are three potential **fibre crops** (kenaf, sesbania and sunn hemp) which could be grown annually during the summer in northern Australia. Sesbania and sunn hemp are legumes. The stems of these species are currently used overseas for the production of paper pulp and there has been considerable research in Australia on their use as feedstock for pulp and paper production. The leaf of these species has reasonable nutritive value and if a pulping industry were to be established in northern Australia the leaf and edible stem material could be a valuable by-product.

Alternatively, all three species could be grown as purpose-grown feedstuff crops, and harvested at an early age to produce an energy-dense feedstuff.

APPENDIX 2
Identified Feedstuffs

A2.1 Agricultural Origin – Australia

▲ Cassava

Species

Manihot esculenta

Crop Description

(See also A2.2)

Perennial shrub grown for its starch-rich tuberous roots which are used for both human and animal consumption. The crop is harvested, dried, and usually pelleted as cassava pellets or tapioca starch pellets for transport, but may be fed to animals as dried chips. Tapioca is a special pelleted form of cassava starch.

History of Crop in Australia

Cassava was first introduced into Australia in the last century as a human food.

Between 1970 and 1985 the energy crisis led to an extensive research and development program (University of Queensland, QDPI, Fielders Ltd and CSR Ltd) investigating the potential for production of starch, stockfeed and ethanol from cassava (Wood et al 1994).

In 1977 Fielders Ltd and CSR Ltd formed Australian Cassava Products Pty Ltd which joined with Bundaberg Sugar Company in 1978, to establish a 750 hectare farm near Maryborough. A mechanical harvester and the technology for large-scale cassava production were developed here. This project terminated in 1987 when, because of lower oil prices, it was concluded that ethanol production from cassava would not be viable.

Some initial research studying the use of cassava in ruminant rations in Australia was conducted by Tudor et al (1985) and Tudor and Inkerman (1986).

Current Production in Australia

Only small areas are grown for local sale as human food.

Nutritional Properties

(See also A2.2)

A typical composition for fresh cassava tubers is:

DM	32% to 37%
ME	12.1 to 14.6MJ/kg
CP	2.6% to 3.6%

A typical composition for dehydrated cassava pellet is:

DM	88%
ME	12.8 to 14.5MJ/kg
CP	2.6%

Cassava tubers contain the cyanogenic glycoside linamarin which is converted to prussic acid (HCN) by the enzyme linamarase. In practice, the glycoside is readily detoxified by hydrolysis during the grating, peeling, slicing, pressing or heating of the tubers.

Cassava is a widely used feedstuff in intensive livestock rations in Europe and Asia, as an energy source.

Costs

No information is available on the likely costs of production under Australian conditions.

Farm Production

The optimum conditions for cassava growth are a warm, moist climate with mean daily temperatures of 25° to 29°C. Growth is reduced at temperatures above 29°C and ceases at temperatures below 10°C. Well distributed annual rainfall of 1000 to 1500mm is desirable but reasonable yields are possible with as little as 500mm. Except during establishment, cassava can withstand prolonged drought. Production is normally restricted to between latitudes 30° N and S and most is produced in the wet season between latitudes 15° N and S (Kay 1973).

Best yields are observed on light sandy soils of medium fertility. On clay soils cassava tends to produce leaf and stem rather than tubers, and although it will grow on low fertility soils, nutrients (particularly potassium) must be applied for high yields. A soil pH in the range 5.0 to 9.0 is suitable for cassava production.

Cassava is readily propagated from short sections of stem and these are usually planted one metre apart in a square pattern, giving about 10,000 plants/hectare. The crop cycle ranges from 9 to 24 months depending on growing conditions and cultivar. When grown for processing it is usually left to attain full maturity at 18 to 24 months after planting, when yields range from 5 to 50 tonnes/hectare of fresh tuber.

In Australia, cuttings were easily machine planted and the crop mechanically harvested. A machine resembling a modified potato harvester was developed to dig and elevate the roots. Harvesting is complicated by the growth of the tubers which can spread up to 120cm wide and 60cm deep.

Post Harvest Operations

Cassava tubers must be processed within about 48 hours of harvest to prevent rotting.

For stock feed tubers are processed into:

- chips – tubers sliced into chips up to 5cm long and in Asia sun dried, usually on concrete slabs
- pellets – dried chips, ground and compressed
- tuber fragments – dried broken roots, similar to chips but thicker and larger.

Feedlot Utilisation

(See also A2.2)

Cassava pellets or chips may be bulk handled and stored with few special facilities required. Attention is required to minimise fines.

SWOT Analysis

Strengths

- High energy feedstuff widely used in Asia and Europe.
- Very palatable.
- Cassava is reputed to produce more starch/hectare under relatively dry conditions than any other crop.
- Cultural requirements for optimal production have been established.
- Suitable planting and mechanical harvesting equipment have been developed.
- Harvest date is not critical, and harvesting can be spread over a fairly long period.
- Processing is simple, infrastructure needs are not large.
- Rarely subject to serious pest and disease problems.
- Little risk of chemical contamination.
- The dried chips are suitable for bulk handling and are readily transported and stored.

Weaknesses

- May compete for land use with sugarcane.
- The crop is slow growing, reaching maturity at 18 to 24 months.
- Harvesting of the deep tubers is slow and costly and poses an environmental risk via soil damage and possible erosion.
- Grows best on light, sandy soils which are relatively rare in areas of Australia with a suitable climate.
- There is a lack of information on yield and production costs in Australia despite earlier trial work.

Opportunities

- High yielding, high nutrient energy crop, well adapted to production in tropical and sub-tropical Australia where grain feedstuffs are difficult to produce.
- May be a suitable high energy feedstuff to grow away from sugarcane areas in northern Australia.

Threats

- May compete with sugarcane for land use. As sugarcane is a well established, relatively simple crop to grow it would need to produce comparable returns or better to become a viable industry in the established farming areas.
- Chemical contamination from adhering soil.
- Soil damage.

Likely Constraints to Production

The main constraint to commercial cassava production in the established farming areas is land use competition with sugarcane and lack of production cost data.

The need to deep dig the crop could be a constraint. Harvesting is both slow and costly, tending to leave the soil bare and subject to soil erosion. Farming systems and varieties would need to be developed to overcome this environmental risk.

Conclusion

Cassava is also reviewed in Appendix 2.2 as a possible import into Australia.

Cassava is already widely grown in many countries and used as an energy-dense stock feed. It appears a promising crop to grow locally as a potential new source of ME for feedlot operations. Cultural requirements have been well researched in Australia.

Preliminary estimates by the University of Queensland using a computer-based cassava growth model indicate that there are some 600,000 hectares with suitable soil and climate for cassava production in Queensland. Much of it lies beyond the established farming areas. There are also large areas of suitable land in the Northern Territory and northern Western Australia.

There are no reliable data on production costs for Australian conditions.

Research and Development Needs

A desktop feasibility study is warranted to assess the physical and financial practicality of growing cassava in Australia as an energy-dense feedstuff for the intensive cattle industries.

A prime requirement is a reliable estimate of cost of production in Australia, possibly extrapolating from overseas experience. This would need to identify suitable production areas and assess cassava's competitiveness with alternative crops which could be grown in that area.

If the study outcome is positive, a pilot operation would be needed to further assess the viability of a commercial cassava industry, examining the introduction of new varieties, such as those with relatively shallow growing tubers.

▲ White Cotton Seed

Species

Gossypium hirsutum

Crop Description

White cotton seed (WCS) is a by-product of the established cotton industry, comprising the remaining seed, hull and usually some lint after the cotton fibre has been removed from the cotton seed boll. In Australia very little cotton seed is delinted.

The product is easily moved, transported and stored in bulk.

Current Production in Australia

The current record cotton crop (approximately 2,600,000 bales) will produce about 850,000 tonnes of WCS at probably 35 gins between Emerald (Q), Trangie (NSW) and Bourke (NSW). Of this, some 350,000 to 400,000 tonnes will be crushed, 200,000 tonnes exported (mostly to Japan) and the balance of 250,000 tonnes distributed to domestic markets. The feedlot industry is expected to consume some 80,000 tonnes to 100,000 tonnes of the domestic distribution.

Future expansion of the cotton industry is expected in north, central and southern Queensland increasing production by probably 650,000 bales cotton or 200,000 tonnes WCS over the next five years. Industry sources believe there is scope in the West Kimberley (and Ord River Irrigation Area) for considerable development in five to ten years, possibly exceeding 1,000,000 bales which would produce more than 300,000 tonnes of WCS. A gin is currently proposed for the West Kimberley, Ord River Irrigation Area.

Extensive and numerous tests on Australian WCS have repeatedly shown it to be free of chemical contaminants (Haire, personal communication).

Nutritional Properties

WCS has a recognised high energy value (National Research Council 1984) due primarily to its high oil content (23%). It also has a high crude protein value. A typical composition is:

DM	92%
ME	14.2 to 14.8MJ/kg
CP	23.0%

WCS is highly palatable to stock.

Ensminger et al (1990) report that WCS can constitute up to 20% of the ration of finishing cattle. Zinn (1996) cites Hale et al (1984), Hale and Swingle (1984) and Huerta-Leidenz et al (1991) and trials evaluating WCS inclusion in rations which consistently showed enhanced ADG and energy intake when WCS is used as a supplement at up to 30% of diet DM.

Huerta-Leidenz et al (1991) fed up to 30% WCS for 54 days in a ration however, without effect on fatty acid profiles of adipose tissue. Zinn (1995) noted WCS at 15% (of diet DM) reduced microbial protein synthesis by 20.5%. Hume (personal communication) relates that there is anecdotal evidence that the feeding of WCS in Australia is associated with the hardening of carcase fat in cattle. This is in contrast with USA experience.

Zinn and Plascencia (1993) demonstrated an interaction between supplemental fat and WCS, concluding that the feeding value of WCS is diminished in growing finishing rations that contain moderate levels (5%) of supplemental fat. This is believed to be associated with a general negative effect of high total dietary fat intake.

Costs

Product cost has varied widely. At $160/tonne (or $174/tonne DM basis) the ME cost is $1.20/100MJ, comparing most favourably with current sources (Table 3.1), particularly when its crude protein qualities are also taken into account.

Feedlot Utilisation

The product is currently quite extensively used in feedlot rations in Australia when commercially attractive. Inclusion levels vary considerably ranging from 3% up to 8%, and occasionally 15% of ration DM.

SWOT Analysis

Strengths

- High energy feedstuff with associated high protein levels.
- Competitively costed source of ME.
- Very palatable.
- Easily handled, transported and stored.

	• With current production practices appears to have no problems of chemical residues.
Weaknesses	• Can combust spontaneously if stored too wet (less than 86% DM) and heaped too high.
	• May develop *Aspergillus* mould , producing aflatoxins, when stored moist.
	• High WCS may conflict with high supplemental fat levels in ration.
	• Virtually unknown maximum inclusion level in rations in Australia.
	• May lead to harder carcase fat (anecdotal evidence).
Opportunities	• A potentially under-utilised high energy feedstuff in Australian feedlot industry.
	• Increasing supplies expected as Australian cotton industry expands, particularly in northern Australia.
	• Treatment with products such as dunder, improves its handling ability for special situations.
	• Potentially valuable feedstuff component in rations for live cattle export markets in northern Australia.
Threats	• In some areas, increased competition from dairy industry usage is likely.
	• Unknown possible effects on carcase qualities at high inclusion levels in ration.
	• Unknown practical maximum inclusion rates.

Conclusion

WCS is a palatable energy-dense feedstuff with associated high protein content, widely available in Eastern Australia at ME costs comparing favourably with currently used ration components. Currently, the feedlot industry uses some 80,000 to 100,000 tonnes annually. There appears to be scope for WCS to be used at higher levels in many instances when competitively costed.

Increasing quantities of WCS will be available in Queensland and northern Western Australia as the cotton industry expands, and this could have positive implications for live cattle export and the feedlot industry in northern Australia.

Research and Development Needs

The principal unknowns which, if satisfactorily resolved, could enable the product to be further used to advantage are:

- Effect of feeding WCS to feedlot cattle on the ultimate carcase characteristics and in particular on fat hardening.
- The maximum satisfactory levels at which WCS can be included both in short and long-term feedlot rations.

▲ Millets

Species

Digitaria exilis (fonio or hungry rice), *Echinochioa frumentaceae* (Japanese barnyard millet), *Eleusine coracana* (ragi or finger millet), *Eragrostis tef* (teff, ingera), *Panicum miliaceum* (common millet, proso), *Pennisetum glaucum* (pearl or bulrush millet), *Setaria italica* (foxtail millet)

Crop Description

The term 'millet' describes a large group of ancient but unrelated species of summer growing cereals, largely originating from and domesticated in Africa (Cobley et al 1976; National Academy of Sciences 1996; Norman et al 1995; Rachie and Peters 1977).

- Pearl millets – Freely tillering, tufted annuals growing up to 3 metres tall, with recently bred dwarf cultivars as short as 1 metre, grown for grain.
- Foxtail Millet – A vigorous, freely tillering annual up to 1.5 metres tall, grown for grain and forage, with the grain being used as bird seed.
- Common Millet – An annual, 30cm to 1 metre tall, whose grain is nutritious and fed to livestock in the USA.
- Finger Millet – A tufted annual growing up to 1 metre tall which is an important staple grain food in parts of India, Uganda and Zambia.
- Hungry Rice – An annual grass grown for forage.
- Tef – A short, tufted annual, 40 to 80cm tall, grown for forage.

History of Crop in Australia

Whilst little grown in Australia, small areas of foxtail millet and common millet are grown in south east Queensland for bird seed.

Current Production in Australia

Information not readily available but production small.

Nutritional Properties

Reported nutritive values for millet grain and hay are:

		Grain	Hay
Millet	DM	86%	85%
(Species not specified)	ME	11.3MJ/kg	8.4MJ/kg
	CP	12.1%	12.5%
Foxtail Millet	DM	89%	87%
	ME	13.9MJ/kg	9.5MJ/kg
	CP	13.1%	8.0%
Common Millet	DM	90%	
	ME	12.7MJ/kg	
	CP	12.9%	
Pearl Millet	DM	90%	
	ME	13.9MJ/kg	
	CP	14.3%	

Costs

Costs of production not available.

Farm Production

Conventional cropping practices and equipment as applied to cereal species are satisfactory to grow millets as grain or forage crops.

• Pearl Millets. Commonly grown in similar climatic conditions to sorghum and can be grown on as little as 250mm rain in growing season. Experimental grain yields reach 4 tonnes/hectare.

• Foxtail Millet. Will produce grain and forage crop with little rain but is less tolerant of poor soils than other millets and intolerant of waterlogging. Grain yields are in order of 0.5 tonnes/hectare.

• Common Millet. Renowned for quick growth and low water requirement, is a source of forage and grain. Grain yields are about 0.5 tonnes/hectare.

• Finger Millet. Grown in India, Uganda and Zambia where it is cultivated in wetter climates and greater altitudes than other millets, with grain yields 5 to 6 tonnes/hectare under ideal conditions. In Uganda, threshed grain yields of 1.8 tonnes/hectare are regarded as average.

• Hungry Rice. Usually grown on land too poor for other cereals. A very small grain with average yields 0.6 to 0.8 tonnes/hectare.

• Tef. Grown as a cereal in the highlands of Ethiopia where the grain is the staple food of the population. In South Africa grown for hay and in India for green forage. The grain yields recorded range from 0.3 to 3 tonnes/hectare. Threshes easily using standard methods and equipment. Grain stores easily with no serious damage from insects.

Post Harvest Operations

Grains stored and handled in conventional manner.

Feedlot Utilisation

Millet grains are generally considered to be equal to sorghum in energy and higher in crude protein and lysine (Ensminger et al 1990).

SWOT Analysis

Strengths

- 'Millets' comprise a range of high energy grains.
- A wide range of genetic material is available for most species.
- Many varieties are promising sources of grain in northern Australia.
- All millets appear to be tolerant of water stress, are well adapted to a wide range of soils, and are capable of producing on low fertility soils.
- The small seed of millet reduces seeding costs.
- Millets are apparently not subject to serious pest and disease problems.
- They are robust, deep rooted and more resilient than sorghum.

	• No major environmental or chemical residue problems are envisaged.
Weaknesses	• Milling of small grain is difficult.
	• Little research has been done in Australia, particularly in northern Australia.
	• Yields vary widely with species, and are generally lower than for established cereals.
	• Limited information is available on agronomic requirements for mechanised production in Australia.
Opportunities	• Potential significant source of grain and high energy feedstuff over much of northern Australia, where current cereal grains perform poorly.
	• Drought resistance provides potential for extending crop production to lower rainfall areas.
Threats	• High value of existing varieties of grain for bird seed trade and as novelty foods.

Likely Constraints to Production

Millets are adapted to a wide range of climatic conditions including areas where they could expect strong competition from established cereal crops, such as wheat and sorghum. To date there is little applied or research experience in the areas considered marginal for other cereals where millets show promise of performing quite well. The value of grain currently produced for human consumption and bird seed makes existing production too expensive for feedlot use.

Conclusion

Millets offer the quite strong possibility of extending grain production into the lower rainfall semi-arid tropics and sub-tropics, and, as such, could be significant sources of high energy feedstuffs in northern Australia.

There is little information on the use of millets for hay or silage production, but the high ME of the grain suggests that hay or silage cut at about the soft dough stage for grain production would be a useful high energy feed.

Research and Development Needs

The millets include species which appear to be capable of significant grain production in northern Australia where current cereal grains perform poorly.

The following further research is recommended:

- Examine in depth the available knowledge to fully ascertain the possible contribution that millets can make as energy dense feedstuffs, particularly in tropical and subtropical areas.
- If this study indicates that they have the potential to aid the intensive cattle feeding industry, field test production systems including harvesting, storage and processing to test commercial viability should be set up.

▲ Kenaf

Species

Hibiscus cannabinus

Crop Description

Kenaf is a traditional fibre crop closely related to cotton, okra, ornamental hibiscus and hollyhock. It has been grown for centuries in China, India, Thailand and Indonesia for its stem fibre which is used for sacks, carpet backing and ropes.

History of Crop in Australia

During the 1950s, USA work identified kenaf as a promising species for pulp and paper production. In the late 1960s exploratory trials established in NSW failed to arouse sustained commercial interest. From 1972 to 1980 CSIRO conducted investigations into its potential as an agro-industrial crop for pulp and paper in the Ord River Irrigation Area. These studies also provided valuable information on its potential for forage production, examining varieties and cultural practices. Complementary harvesting studies were conducted in Queensland using sugar cane and forage harvesters.

There is no Australian work on the feeding value of kenaf leaf material but data from USA indicates a comparable value with lucerne (Swingle et al 1978; Phillips et al 1990).

Current Production in Australia

No current commercial production.

Nutritional Properties

Feeding trials in the USA and Thailand have studied kenaf leaf as a meal, silage, hay and ground hay, and found kenaf leaf and young stem material has "good" nutritional value and is readily eaten by stock (Knowles et al 1974; Wing 1967; Pinkerton 1971; Suriyajantratong et al 1973; Swingle et al 1978). A typical composition of kenaf leaf and young stem material is:

DM	89%
ME	7.2 to 10.0MJ/kg
CP	11.0% to 20.0%

Nutritive values decline rapidly with increasing plant age.

Costs

Cost of production data are not available. Assuming a price of about $150/tonne dried young material delivered to the feedlot, an estimated cost of ME would be $1.69 to $2.34/100MJ, comparing marginally with currently used feedstuffs (Table 3.1).

Farm Production

Kenaf is a very fast growing species adapted to a wide range of soils and climates. It grows best in the tropics and sub-tropics where mean daily temperatures during the growing season exceed 20°C (Killinger 1969; Kirschbaum 1995; Mandow 1981). It is normally grown as a row crop from seed over the wet or summer season, and has good tolerance to water stress and moderate salinity.

Under good growing conditions kenaf will produce up to 30 tonnes stem DM/hectare and 5 tonnes leaf DM/hectare in six to eight months. Australian irrigated production yields are highest in northern and inland areas with high solar radiation and long frost-free periods. Potential yields are greatly reduced under dry land conditions except where good rains together with high temperature and fairly high radiation exist, such as in the top end of the Northern Territory.

When grown for fibre production, it is harvested with a heavy duty forage harvester soon after the commencement of flowering (Hazard et al 1988). If grown as a fodder crop, it should be harvested about two months after sowing. It could be mowed, windrowed, and baled as a hay crop or harvested with a forage harvester and either ensiled or artificially dried and baled. In northern Australia three or four crops could be grown annually with irrigation.

No serious pest or disease problems.

Kenaf is grown for pulp and paper production in Thailand and the USA. The utilisation of the by-product leaf material for stock feed would greatly improve the commercial prospects of the crop for pulp and paper.

Post Harvest Operations

There are three production options.

• Field-baled hay. Purpose grown kenaf could be cut, crimped, windrowed and allowed to dry to 85% to 89% DM, baled in the field, transported and stored. Expected yields are 5 tonnes DM/hectare after 60 days, with two to four crops annually under irrigation in northern Australia.

• Forage harvested with artificial drying. Purpose grown kenaf is forage harvested, artificially dried and leaves and larger stem material separated. This requires on-farm drying, separating and baling facilities or a larger scale centralised processing facility. Yields of up to 5 tonnes DM/hectare containing up to 60% leaf material of high quality would be expected at each harvest.

• Leaf as a by-product of pulp and paper production. This involves salvaging the top leaves cut off the crop immediately prior to harvesting the stem for pulp, and is dependent on there being an associated pulp and paper industry. The tops would be cut using a topper, and compacted for transport to a centralised processing plant where they would be partially dried. The leaves and smaller branches would then be separated. Separated leaves and edible stem material would then be either dried to 10% to 12% moisture content and baled or ground and pelleted.

Feedlot Utilisation

Kenaf could be purpose-grown and field baled, and then processed at the feedlot site. The forage harvested and leaf by-products would require drying, then baling or pelleting. Conventional facilities for transport, storage and processing would be satisfactory.

SWOT Analysis

Strengths

- Reasonable ME source when harvested young.
- Very fast growing and high yielding over a range of soils and climates.
- Extensively researched in Australia enabling easy selection of suitable cultivars and cultural practices.
- Well adapted to summer rainfall areas providing complete ground cover, eliminating weeds and reducing the risk of soil erosion.
- Tolerant of water stress and of moderate salinity.
- Without serious pest or disease problems.
- Can be grown and harvested with conventional farm machinery.

Weaknesses

- Harvesting and processing procedures need to be developed and refined.
- The large biomass production requires high fertiliser inputs.
- Relative low density of hay incurs higher cartage, storage and processing costs; double dumping of bales may assist.
- Unless purpose grown, leaf could only be utilised as a feedstuff if produced as a by-product of a pulp and paper industry.

Opportunities

- A crop which can excel in northern Australia as a purpose-grown hay crop, or as a crop grown as a pulping feedstock.
- A non-woody fibre crop alternative providing a reasonable nutrient energy source in its leaf by-product for farmers seeking to diversify production systems.

Threats

- Development of a kenaf leaf by-product meal industry would be dependent on the successful establishment of an associated pulp and paper industry.

Likely Constraints to Production

There needs to be a pulp paper industry based on kenaf for the leaf by-product to be produced. Alternatively, it could be purpose grown and harvested as an immature plant for forage.

Conclusion

Overseas feeding trials suggest that kenaf leaf and edible stem material have potential as an energy feedstuff for cattle. Kenaf purpose-grown as a forage crop and harvested at about 60 days, offers the prospect of a relatively high energy feedstuff able to be grown over much of Australia, particularly in the north under irrigation, or dryland where rainfall is adequate.

Kenaf leaf meal could also become available as a by-produce if a pulping industry was established in close proximity to feedlot enterprises.

Research and Development Needs

The nutritive value of kenaf in relation to age needs further definition when purpose grown as a forage crop.

The viability of kenaf as a purpose-grown forage crop, and the practices for harvesting, storage and processing need further examination to assess its potential value to the Australian intensive cattle industries, particularly in northern Australia. In that area in combination with other feedstuffs it may be a cost-effective nutrient energy source.

▲ Sunn Hemp

Species

Crotalaria juncea

Crop Description

The *Crotalaria* sp. are widespread throughout the tropics and sub-tropics and, to a lesser extent, in temperate areas. Sunn hemp, one of the traditional best fibre crops, is an erect, herbaceous annual legume which can grow to four metres. It is grown in India, the world's major producer, largely for fibre and also for forage and as a green manure crop.

White and Haun (1965) report a wide diversity in seed stocks in respect of morphology, phenology, disease, pest resistance and yield.

History of Crop in Australia

Sunn hemp has not been grown commercially in Australia.

Current Production in Australia

There is no commercial production in Australia.

Nutritional Properties

There are no reported data, however young plants and leaf material are assessed to have high digestibility and ME of about 10MJ/kg. As a legume, the CP content should also be quite high, but White and Haun (1965) report CP of 5.5% in a high yielding (presumably mature) crop.

Seed of several species of *Crotalaria* is reported to contain a toxic alkaloid. There are conflicting reports on the toxicity of sunn hemp, but it is understood the seed of modern cultivars is non-toxic.

Costs

There are no data.

Farm Production

Sunn hemp grows best in tropical sub-tropical conditions preferring well drained alluvial soils with sandy loam or loamy texture. Broadcast or sown as a row crop, early growth is rapid, generally smothering most weeds.

As a legume with resistance to root knot nematodes, it would fit well into semi-arid tropical and sub-tropical crop rotation systems in areas suitable for grain sorghum or millets. Lighter textured soils in higher rainfall areas would be most suitable. (Blain sands, Tippera clay loams of the Douglas-Daly, NT). A number of *Crotalaria* species occur as weeds in Australia, but sunn hemp is apparently no problem in this regard.

There is considerable genetic variation in flowering response with most varieties ready for harvest 120 to 150 days after sowing when pods have formed.

Sunn hemp offers two options as an energy dense feedstuff:

- as a purpose-grown forage crop harvested about two months after sowing when digestibility and ME should be high;
- as a by-product of a pulp and paper industry.

Post Harvest Operations

When purpose-grown as a forage crop, all harvested material could be baled or perhaps ground and pelleted.

As a by-product of pulp and paper production, leaf material would need to be separated, dried and then baled or pelleted.

Feedlot Utilisation

As a purpose grown forage crop, harvested early.

SWOT Analysis

Strengths	• Potentially a hardy tropical or sub-tropical crop offering a reasonable level of ME. • Will grow on poor soils and is fairly drought resistant. • In some varieties, has a high level of resistance to root knot nematodes. • As a legume, can fix atmospheric nitrogen to meet its nutrient requirements.
Weaknesses	• Problems experienced in obtaining good crop stands. • Shows some tendency to lodge. • Sensitive to cool temperatures. • Yields are lower than other fibre crops, eg. kenaf.
Opportunities	• A potential early-harvested energy feedstuff for northern Australia.
Threats	• No serious threats apparent.

Likely Constraints to Production

Competition from higher value cereal crops and from higher yielding fibre crops offering similar opportunities.

Conclusion

Although little is known of sunn hemp in Australia, it appears to have prospects as a forage crop in northern Australia, or as a by-product of a paper pulp industry, in common with kenaf.

Research and Development Needs

The nutrient value of sunn hemp purpose-grown as a forage crop needs further definition. In particular, the effect of crop age on feeding value needs to be established.

The viability of sunn hemp as a purpose-grown forage crop, and the practices for harvesting, storage and processing need further examination to assess the crop's potential value to the Australian intensive cattle industries. This is particularly important in northern Australia, where in common with other feedstuffs it may be a cost-effective nutrient energy source.

▲ Leucaena

Species

Leucaena leucocephala

Crop Description

A perennial leguminous shrub native to Central America which is used throughout the tropics as an animal feed (Jones et al 1992).

History of Crop in Australia

The crop has been commercially exploited in Australia since the 1960s as a grazing crop. Its acceptance and utilisation by the grazing industry has been slow.

Current Production in Australia

There are some 35,000 hectares established to leucaena, mostly in coastal and inland Queensland, with a small area in WA (Ord). The total area is used exclusively for cattle grazing supporting some 50,000 head (Middleton et al 1995).

Nutritional Properties

The digestibility of edible (leaves and small stems) dry matter (EDM) is 55% to 70%. A typical composition of the EDM is:

DM	90%
ME	7.8 to 10.0MJ/kg
CP	18.0% to 25.0%

The chemical composition of leucaena EDM is generally similar to lucerne *(Medicago sativa)* with a low sodium content 0.01% to 0.05%. Leucaena contains some tannins and the amino acid mimosine, which when metabolised to dihydroxy pyridine (DHP) can cause problems in both ruminant and non-ruminant animals. This toxicity may be overcome in cattle by rumen inoculation.

Costs

Production cost data for harvested EDM are not available. If leucaena hay or its dry equivalent is assumed to have a similar production cost to lucerne hay, namely $150/tonne, the estimated cost of ME is $1.67 to $2.14/100MJ, which compares marginally with currently used established industry feedstuffs (Table 3.1), but possibly quite favourably with northern Australian alternatives.

Farm Production

Maximum production is achieved only under conditions of high soil fertility and adequate moisture. Leucaena will not grow well on acid soils. In Australia, it is grown mostly on alkaline clay soils with 600mm to 750mm annual rainfall. There are small areas under irrigation. Growth in the subtropics may be restricted by cool winter temperatures and frost.

Since the mid 1980s an insect pest (the leucaena psyllid) has reduced yields by up to 50%. New cultivars with some resistance to the psyllid are becoming available.

Mechanical harvesting practices have only been used on an experimental basis.

Under experimental conditions annual yields have been as follows:

- 7 tonnes leaf DM/hectare in north Queensland with the crop grown in hedgerows and harvested monthly using a tea harvester;
- 13 tonnes EDM/hectare in north Queensland with current cultivars under coppicing (not accounting for any effect of the psyllid);
- 20 tonnes total DM/hectare in Hawaii cutting close to ground. EDM not recorded.

Post Harvest Operations

Post harvest, the harvested material has to be dried. The leaflets shed very readily on drying, eliminating the possibility of conventionally baling as hay. Production of silage could be an alternative but there is no information on silage production from leucaena.

Feedlot Utilisation

Leucaena may have a place as a source of energy, protein and roughage in northern feedlot rations. The harvesting and feeding of green chop (or perhaps silage) may be an option in northern Australia if grown close to the feedlot. The most practical option may be to harvest, dry and possibly compress for storage on the feedlot site.

SWOT Analysis

Strengths

- Source of dry matter with reasonable energy and crude protein levels in northern Australia.
- On assumptions made it is a reasonably costed source of ME.
- A long-lived perennial capable of producing a high DM yield with regular forage harvesting.
- Suitable agronomic and management practices have been established, and preliminary mechanised harvesting systems have been developed at research level.

Weaknesses	• Costs of production, harvesting and storage are unknown. • Current cultivars (and thus established stands) are susceptible to psyllid. • Psyllid resistant cultivars becoming available may have different nutritive value than current cultivars. • Needs fertile, well drained soil for high production. • Successful establishment can be difficult. • No commercially proven harvesting methods available nor storage systems, although research to date promising. • Toxicity due to mimosine/DHP. • Transport from farm to feedlot may be expensive.
Opportunities	• In northern Australia there are an estimated 2,000,000 hectares suitable for leucaena establishment. • Mimosine/DHP toxicity can be prevented with rumen inoculation of 10% of stock. • There is potential for higher yielding psyllid resistant cultivars. • Suitable commercial harvesting from hedgerows could be developed. • Suitable processing and storage technology could be developed (eg. pelleting).
Threats	• Psyllid attack.

Likely Constraints to Production

The main constraint to intensive leucaena production is probably the lack of suitable soils required for high yielding plantation crops in high rainfall or irrigated areas in northern Australia. The need to counter DHP toxicity must also be considered. The psyllid insect has had an adverse effect on leucaena production.

There is a lack of knowledge on harvesting and storage procedures suitable for the intensive cattle feeding industry.

Conclusion

Leucaena is a potential source of ME in northern Australia as a purpose-grown crop but harvesting, processing and storage practices need to be further developed. Currently, there is a lack of applied production knowledge limiting its commercial development for the feedlot industry.

Research and Development Needs

Although much research appears to have been completed with respect to leucaena and its use for the grazing industries, there is inadequate development for its ready use in an intensive cattle feeding industry.

Further research would need to:

- develop harvesting and storage procedures
- determine production costs, cost of product, and the nutritive value of the harvested material
- establish the nutritive values of psyllid resistant species.

▲ Sesbania

Species

Sesbania spp

Crop Description

Weedy, fast growing leguminous shrubs, widely distributed in the tropics and subtropics. Sesbania is rarely grown commercially except in India where a number of species are used as green manure crops and as forage, firewood and pulpwood for fibre industries (Rotar and Evans 1986; Wood and Larkens 1987).

History of Crop in Australia

Ten species are native to northern Australia but none is used commercially.

Current Production in Australia

A cultivar of *Sesbania sesban* has been released by the University of Queensland as a forage crop but there is no record of current production.

Nutritional Properties

The leaf material would be comparable with lucerne and leucaena, and a typical composition is:

DM	90%
ME	10.8MJ/kg
CP	24.0%

Costs

As for leucaena, information on cost of production is unavailable. If similar assumptions are applied as for leucaena, an estimated cost of ME is $1.54/100MJ, comparing favourably with established sources (Table 3.1).

Farm Production

Sesbania grows on a wide range of soil types, favouring heavy textured and high moisture soils. It is readily established with conventional planting equipment. Many species make very rapid early growth.

It appears to be subject to few diseases or insect pests.

If grown for feedlot use, it could be grown in hedgerows and mechanically harvested with the harvester straddling the hedgerows, cutting the top off the plants and passing it to a storage bin, in the same manner as proposed for leucaena.

Post Harvest Operations

Harvested material would have to be dried and baled, or ground and pelleted.

Feedlot Utilisation

The feeding qualities and handling of sesbania parallel leucaena, with less problems of toxicity.

SWOT Analysis

Strengths	• Reasonably high energy feedstuff with potential for northern Australia. • Readily established from seed and fast growing on a wide range of soil types and moisture conditions. • Appears subject to few diseases and unattractive to most insect pests. • Offers low risk of chemical residues. • A large germplasm collection is held in Australia.
Weaknesses	• Cost of production unknown. • The most promising forage species appear to have a fairly short lifespan (about two years). • Information on growth and yields under intensive harvesting is lacking. • Commercial harvesting, processing and storage systems need to be developed. • Information on the likely viability of a production system is not available.
Opportunities	• Could form the basis of a large-scale tropical forage industry for the feedlot or associated industries.
Threats	• No serious threats can be foreseen at this stage.

Likely Constraints to Production

The major constraint to production is a lack of commercial information on commercial productivity and production costs, particularly harvesting and storage.

Conclusion

Sesbania is a forage species offering promise as a feedstuff for a feedlot industry in northern Australia. Its tolerance of poor soil conditions, its capacity to fix nitrogen and its apparent resistance to insect pests and diseases are valuable attributes. However, research and development work is required to assess its potential as a commercial feedstuff.

Research and Development Needs

Studies are required to:

- confirm growing, harvesting and storage procedures and practice
- ascertain the nutritional value of the leaf and stem material
- establish the likely yields under intensive harvesting, and determine production costs and comparative attractiveness as a feedstuff.

▲ Chickpeas

Species

Cicer arietinum

Crop Description

Chickpeas are one of the most widely grown grain legumes (pulses) in the world, principally for human consumption. An annual herbaceous winter grown crop, it is also useful for breaking disease and weed cycles in cereal rotations. There are two main cultivars of chickpea, namely 'desi', with small coloured seed and mainly grown in India, and 'kabuli', with large light coloured seed, mainly grown in the Mediterranean.

Pulses are highly digestible and palatable and high quality sources of both energy and protein for livestock.

History of Crop in Australia

Chickpeas are well adapted as a dryland winter crop in temperate and sub-tropical areas. Commercial production began in Australia in the late 1970s when the Indian 'desi' cultivar, Tyson, was released. The industry grew rapidly during the 1980s with production peaking in 1991-92. It has since tended to decline as a result of lower prices and some disappointing yields.

Current Production in Australia

Most of the crop is grown in Queensland, followed by NSW, Victoria, South Australia and Western Australia (GRDC 1994).

Appendix Table 3 Australian chickpea production

	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95
Area ('000 ha)	93	178	250	145	127	162
Production ('000 tonnes)	109	192	223	172	164	???

Most of the chickpeas produced in Australia are exported to Indian, Middle East and European markets for human consumption.

Nutritional Properties

A typical composition is:

DM	89%
ME	13.2 to 14.4MJ/kg
CP	21.4%

Chickpeas have high protein and fibre digestibility, high fat content and are richer in phosphorus and calcium than other pulses (GRDC 1994).

Costs

The cost of chickpeas in December 1996 was $210/tonne, equivalent to $236/tonne DM. On this basis the cost of ME is $1.71/100MJ which compares marginally with currently used feedstuffs (Table 3.1).

However $210/tonne is a low price with growers hoping for up to $400/tonne, lifting the cost of ME to an estimated $3.26/100MJ. On 1996 costs, $210/tonne would return a gross margin to the farmer of about $73/tonne which compares unfavourably with other winter crops (NSW Agriculture 1996c).

Farm Production

Chickpeas grow on well-drained loam, clay loam and heavy self-mulching soils.

The crop is subject to diseases such as *Fusarium* wilt and is highly susceptible to attack by *Heliothis* caterpillars.

Yields should average about 1.7 tonnes/hectare.

Post Harvest Operations

Conventional grain handling and storage.

Feedlot Utilisation

Human consumption of chickpeas in Australia is limited to the 'kabuli' type. Australia is one of the largest exporters of 'desi' type chickpeas and the longer term growth in demand for 'desi' is likely to be for stock feeds (AIAS 1990). It would appear Australian feedlots would have to pay some $300/tonne for chickpeas to remain attractive to Australian farmers, or $2.44/100MJ of ME plus protein.

SWOT Analysis

Strengths

- Digestible and palatable high energy feed.
- Agronomic and management requirements well known.
- Offers opportunity for pest/disease control in winter crop farming rotations.
- A nitrogen-fixing legume in crop rotations.

Weaknesses

- Quite a high cost source of ME.
- Anecdotal evidence indicates that it can cause carcase fat yellowing.
- Attacked by *Heliothis.*
- Subject to price variation.
- Requires fertile soils and so competes with high return crops.

Opportunities

- Further promotion as a winter legume in crop rotations.
- Long term use of 'desi' away from human consumption towards stock feed.

Threats

- Other winter crops may offer higher returns to farmers.
- 'Kabuli' chickpeas for human consumption are an attractive crop alternative to 'desi'.

Likely Constraints to Production

Competition from other winter crops. When prices of chickpeas are low enough to be attractive for feedlot consumption, they may be too low to be a sound economic alternative for growers.

Conclusion

In common with other pulses, chickpeas offer a valuable part source of ME for feedlot rations. Potential exists for increased production of the 'desi' type for stock feeds provided adequate returns are maintained to the grower. There appears scope for greater use of chickpeas in feedlot rations only on an opportunity basis. The anecdotal evidence suggesting chickpeas can cause carcase fat yellowing should be noted.

Research and Development Needs

No research and development warranted.

▲ Cowpea, common

Species

Vigna unguiculata

Crop Description

Current cultivars range from largely determinate, short, erect herbs to prostrate vining plants with stems up to several metres long and indeterminate flowering habit.

The erect, determinate types set ripe pods in as few as 55 days after sowing and are more suited to grain production.

The vining, indeterminate types can be useful forage crops (Imrie 1991, 1994).

History of Crop in Australia

Cowpeas are believed to have originated in Africa. They have been grown in Australia for many years as both a hay and a grain crop.

Current Production in Australia

Cowpea production in Australia is limited. About 85% is grown in NSW and the remainder in Queensland. Predominant use is as a pulse with the dried seeds ground into flour or cooked and consumed whole. Gradings and poor quality seed are used as stock feed.

Some production details are shown in Appendix Table 4:

Appendix Table 4 The area and production of cowpea Australia

Year	Queensland (ha)	NSW (ha)	Total Area (ha)	Total Production (tonnes)
1983-84	2,859	5,038	7,897	3,757
1985-86	1,500	6,858	8,358	3,231
1987-88	4,422	19,000	23,422	12,000
1990-91	200	4,700	5,000	4,000

Nutritional Properties

The nutrient value of cowpea grain compares closely with other grain legumes, such as peas, beans and lupins.

A typical composition of the grain and dehydrated pods is reported to be:

	Grain	Dehydrated Pods
DM	89%	92%
ME	13.6MJ/kg	12.3MJ/kg
CP	22.0% to 30.0%	23.5%

As with most legume seeds, the content of sulphur-containing amino acids, particularly methionine, is low.

Cowpea hay is reported to contain 8.9MJ/kg of ME. However, in common with other legumes, the energy content can be expected to vary with the age at harvest. At the early pod stage the ME could exceed 10MJ/kg.

Cowpea stems are softer, and become less woody and lignified with maturity than many warm season legumes, such as lablab.

Costs

NSW Agriculture (1996c) projected variable costs for the 1996-97 crop as $163/hectare for an estimated average yield of 0.8 tonnes/hectare. Of this yield, 80% could be expected to be sold for approximately $550 delivered container at terminal. At $550/tonne ($618/tonne DM), the cost of ME would be high at $4.54/100MJ. The remaining 20% of the yield however would be graded out and sold at an expected $220/tonne. Assuming the ME of these gradings to be about the same as for the pods and seeds, the ME cost could be estimated at $2.00/100MJ, which may have marginal appeal.

Farm Production

Cowpea is a summer legume grown from seed with rapid germination and establishment under warm conditions, suited to lighter textured soils where moisture may be marginal. Cowpea is susceptible to water logging.

Cowpeas are subject to attack by a wide range of pests, necessitating insect control for the production of high quality grain. Grasses and some broadleaf weeds are controlled by trifluralin, the only herbicide registered for use with cowpeas.

Grain maturity is very dependent on soil and climatic conditions, and where moisture is adequate for growth, the crop tends to continue producing new leaves and flowers, possibly requiring the application of a desiccant before harvest. Care is needed with harvest and post-harvest grain handling as the large seeds are easily cracked and broken.

The average Australian grain yield in the period 1987 to 1992 was 0.4 tonnes/hectare.

Post-harvest Operations

Stored grain requires protection from Bruchid beetles which are becoming increasingly common in northern Australia as grain production increases.

Feedlot Utilisation

The cowpea grain is a suitable source of energy and can be readily handled.

SWOT Analysis

Strengths

- A high energy feedstuff, with complementary high protein value.
- Well suited to lighter textured soils in subtropical and temperate areas, where moisture is likely to be marginal for other summer crops.

Weaknesses

- Susceptible to waterlogging.
- Subject to attack from a broad spectrum of diseases and insect pests.
- Grain used mainly for human consumption therefore probably only wastage or gradings available at a competitive cost for feedlot use.

Opportunities

- Could be some opportunity for cowpea hay production.

Threats

- Because of human consumption, price is generally non-competitive for feedlot use.
- Chemical residues in both hay and grain.

Likely Constraints to Production

The major constraint to production of grain or forage for feedlots is the high value of the grain for human consumption. The need to control insect pests poses a risk of chemical residues in both grain and hay.

Conclusion

Both grain and hay would be useful high energy stock feeds but, because of demand for cowpea for human consumption, would be too expensive for feedlot use.

Research and Development Needs

No research and development warranted.

▲ Lucerne

Species

Medicago sativa

Crop Description

Lucerne is a perennial legume widely grown in all Australian states in pure stands or as lucerne/grass mixtures. It is used in the livestock industries as special purpose grazing pasture or as hay, silage, green fodder, pellets or cubes.

History of Crop in Australia

Lucerne has been grown since the early settlement in coastal areas and the establishment of the merino sheep industry in NSW. The cultivar Hunter River, derived by natural selection from imported seed, was the only cultivar available until the 1960s. Lucerne plantings in Australia peaked in the early 1970s, declining with increased cropping and the arrival of damaging aphid pests in 1977-78. Since then, intensive plant breeding programs have produced new cultivars with greatly improved disease and insect resistance and higher productivity, particularly in winter. Plantings have again tended to increase.

Current Production in Australia

Over 1,000,000 hectares are sown to pure lucerne, mainly in NSW, Queensland, Victoria and South Australia. About 90,000 hectares in NSW and 25,000 hectares in Queensland are specifically managed for hay, largely with the aid of irrigation.

Nutritional Properties

Nutritional qualities vary seasonally due to a higher stem content in summer. Typical hay compositions are:

	Mid-Spring	Mid-Summer
DM	90%	90%
ME	8.4 to 10.0MJ/kg	7.2 to 8.4MJ/kg
CP	24.0%	14.0%

Costs

The cost of hay is very seasonal, varying between about $125 and $250/tonne.

Assuming an average cost of $150/tonne ($166.67/tonne DM), the cost range of ME is $1.67 to $2.32/100MJ which is marginal compared with currently used feedstuffs (Table 3.1), as the prime product can be expected to well exceed average cost.

Farm Production

Lucerne prefers deep, neutral to slightly alkaline, well drained soils of medium to light texture. While it will tolerate a wide range of temperatures, it is basically best suited to a Mediterranean climate, with reasonable production between 10° and 30°C. It is frost tolerant and unsuited to tropical areas with high rainfall and high humidity (McDonald and Waterhouse 1988; Thompson and Paull 1990).

Well managed lucerne stands are long lived with persistence depending on location and soil type.

Average hay yields vary. Whilst good commercial growers produce over 15 tonnes/hectare annually, average yields are closer to 8 tonnes/hectare. Winter-active varieties are available to maximise yields. Adverse weather conditions often reduce hay yields.

Post Harvest Operations

In the non-grazing environment lucerne is usually harvested as hay and the technology for hay and silage making is well developed. There is in addition a small pelleting and cubing industry.

Feedlot Utilisation

Lucerne is commonly used in the feedlot industry as a protein-rich roughage, which is usually processed on the site. Bloat is a potential problem, which good management can avoid.

SWOT Analysis

Strengths

- A palatable high quality roughage combining reasonable energy levels and protein.
- The lucerne hay industry is well established, and agronomic and management practices are well known.
- New cultivars combine high yield with improved disease and pest resistance.
- The perennial nature of lucerne is such that, in favourable environments, well managed stands are long lived.

Weaknesses

- Lucerne, as a source of ME, is relatively more expensive than commonly used alternatives.
- Cartage, storage and further processing of hay is expensive.
- High yields of high quality hay necessitate irrigation.
- The newer, winter-active varieties produce hay with greater stem content (and therefore lower quality).
- Hay quality and yield vary with season, and weather condition, and are easily downgraded.
- A range of diseases/pests can shorten stand life and reduce hay quality.
- Bloat can be a problem.
- High quality silage is difficult to make.

Opportunities

- In select areas, a potential energy source when harvested as a prime product and combined with other positive nutrient qualities.
- Disease/pest resistance can be further improved by plant breeding.
- Hay quality could be improved by improving stem digestibility.

Threats

- New pests and diseases may emerge, challenging the available resistant cultivars.
- There has been a decline in the availability of suitable irrigated land.

Likely Constraints to Production

A shortage of suitable irrigated areas for industry expansion is developing, as alternative land uses, such as for horticulture, offer more remunerative returns.

Conclusion

Lucerne is a valued high quality forage or a roughage hay. There are high costs associated with the cartage, storage and processing of hay, and a summer decline in quality means energy levels are often less than desired. The special purpose use of pellets and cubes to aid transport and storage is generally a high cost option.

Research and Development Needs

No research and development warranted.

▲ Temperate Pasture Species

Species

Includes:

• Temperate grasses in several genera including *Bromus unioloides: Chloris spp; Cynodon hybrid; Dactylis spp; Festuca spp; Lolium spp; Paspalum dilatatum; Penniselum clandestinum; Phleum spp.*

• Temperate legumes in several genera including *Aeschynomene spp; Lotus spp; Medicago sativa* (lucerne – see previous section)*; Trifolium balansae; Trifolium hybridum; Trifolium pratense; Trifolium repens; Trifolium resupinatum; Trifolium subterraneum.*

Pasture Description

The species identified above are fast growing annual and perennial grasses and legumes. Only those species that are suited to high rainfall or irrigation, and that have the highest production of dry matter, are considered.

History of Temperate Pastures in Australia

Native pastures are usually deficient in legumes such as clovers and medics and have slow growth and poor feed quality. They are often only a relatively unpalatable and low quality remnant of the original vegetation.

Improved temperate pastures in Australia, in contrast with most other countries, are almost entirely based on exotic species in simple mixtures with legume components supplying nitrogen. In contrast, many overseas pastures are sown with complex mixtures of native species, have ä substantial part of their production conserved, are fed to housed stock and have nitrogenous fertiliser applied.

Current Production in Australia

Sown pastures and forage crops occupy some 12% of agricultural land outside the arid pastoral zone.

Nutritional Properties

Normally grass components of pastures contribute low nutrient energy (good quality Ryegrass hay provides approximately 8MJ/kg ME), while some legumes can contribute as high as 10MJ/kg ME in the fresh, early vegetative stage.

Ladino white clover *(Trifolium repens)* in the early vegetative stage is an example.

DM	20%
ME	10.0MJ/kg
CP	27.0%

Costs

Yields and costs of white clover pasture under experimental conditions (Michalk 1977) indicate ME in the order of $1.33/100MJ.

Farm Production

Improved temperate pastures are used almost entirely for grazing. The potential exists for their increased use as an ensiled component.

Post Harvest Operations

Ensiled or hay.

Feedlot Utilisation

Could be used in some temperate areas as an ensiled component.

SWOT Analysis

Strengths

- Temperate pastures offer a wide range of species and cultivars suitable for a wide range of environments
- Young leafy material is a seasonal source of ME.
- Selected species can produce very high DM yields of reasonably high energy, high protein, palatable feedstuff.

Weaknesses

- Low DM and hence high freight costs.
- Would require use as silage, as hay is excessively expensive.
- Quality decreases rapidly with increased harvest interval.
- Some species have possible toxicity problems.
- An expensive source of ME.

Opportunities

- Could be grown in areas of suitable high rainfall or in irrigation areas.

Threats

- Increases in fertiliser costs could affect economic viability.

Likely Constraints to Production

The main constraint is likely to be the normal difficulties associated with pasture silage production and transport costs.

Conclusion

While temperate grasses are unlikely to be a major energy source for feedlots, some temperate legumes could be valuable supplementary energy sources. Their low DM and need to ensile to ensure continuity of supply necessitates that they be grown near the feeding operation. Their use in a feedlot will be largely location and site specific.

Research and Development Needs

No research and development warranted.

▲ Tropical Pasture Grasses

Species

Includes:

• Tropical grasses in several genera including *Cenchrus ciliaris,* buffel; *Chloris gayana,* rhodes; *Cynodon dactylon,* bermuda; *Digitaria eriantha; Panicum maximum,* panicum; *Paspalum spp.,* paspalum; *Pennisetum purpureum,* napier (elephant); *Setaria sphacelata* , setaria; *Sorghum spp.* forage sorghum ('t Mannetje and Jones 1992).

Grass Description

These tropical pasture grasses are fast growing perennials, most of them tall, tufted grasses.

History of Tropical Pasture Grasses in Australia

Purposeful plant introduction since the 1930s has made a wide range of introduced grasses available to the tropical and sub-tropical Australian grazing industries. Most are of African origin with many accidentally introduced in the early 20th century.

Current Production in Australia

Introduced tropical pasture grasses are restricted to relatively small areas in relation to the total area available, mostly in Queensland (4,000,000 hectares) and smaller areas in the Northern Territory, where they are used for cattle grazing, sometimes in conjunction with associated legumes. Some small areas are used for hay production.

Nutritional Properties

The general digestibility of young (two week) regrowth of tropical grasses is about 70%, decreasing rapidly to about 55% at six weeks. Stems are much less digestible than leaves. These digestibilities imply nutrient values for well made hay as:

	2 Weeks	6 Weeks
DM	90%	90%
ME	10.0MJ/kg	7.5MJ/kg
CP	18.0% (leaves)	4.0% (leaves and stem)

Tropical pasture grass hay is generally of low quality because it is made from mature plant material and includes the less digestible stem. Some tropical grasses contain chemicals with adverse effects (eg. setaria - oxalic acid; sorghum - HDC).

Costs

Reliable information for hays is largely unavailable.

Farm Production

In Australia tropical grasses are used almost entirely for grazing. All have been harvested as hay in other countries but are rarely suitable for silage due to difficulties in compaction, lack of lactic acid production during fermentation, and low quality of final product.

Yields are very variable, depending on moisture, fertiliser and temperature. With very little moisture stress or under irrigation, yields to 40 tonnes DM/hectare annually have been reported with high applications of fertiliser (N, P at least). The highest yields are reported from longer cutting intervals of eight weeks or more, when quality is acutely diminished.

The utilisation of tropical grasses as an energy source requires harvesting young leaf possibly every four weeks, but cutting at these shorter intervals severely reduces DM yields.

Post Harvest Operations

Hay, stored conventionally.

Feedlot Utilisation

These grasses would require harvesting and storage as hay made at early stage of growth.

SWOT Analysis

Strengths
- A wide range of cultivars exist, about which much is known.
- Can produce very high DM yields.
- Young leafy material is of reasonably high nutrient energy quality.

Weaknesses
- Quality decreases rapidly with increased harvest interval.
- Hay and silage is traditionally not of high quality as cut when too mature.
- Lack of knowledge of how to efficiently harvest, store and process to preserve maximum nutritive values and make available to intensive livestock feeding industries.
- Some species have possible toxicity problems.

Opportunities
- Can be grown in areas of suitable high rainfall or in irrigation areas in northern Australia.
- Improved management, harvesting, processing provides access to reasonably high energy feedstuffs.

Threats
- Increases in fertiliser costs could affect economic viability.

Likely Constraints to Production

In addition to competition with crops such as sugarcane, there is likely to be difficulty in maintaining a regular harvest and supply for feedlot use unless satisfactory harvesting and storage practices are developed. In the past, attempts to use freshly harvested sorghum for an Ord feedlot encountered problems when harvesting was interrupted during the wet season. Current northern industry harvesting practice is usually to harvest when the crop is too mature with a resultant inferior product.

Conclusion

There is a large number of tropical grasses for which much is known about their cultural and technical agronomic features. Many of these are high DM producers and when harvested at the young stage are a potential source of high energy feedstuffs. To date most harvesting, largely as hay, has been at the mature stage where DM yields have been maximised but quality has been low.

Harvesting methods, transposed from the temperate areas, have been largely unsuccessful in attaining a quality stored product.

The greatest constraint to the development of the use of tropical grasses in intensive feeding systems appears to be the lack of suitable applied practical knowledge on harvesting and storage at their optimum stage of growth.

Research and Development Needs

The return on further investment in using tropical grasses for the feedlot industry appears minimal, unless harvesting and storage systems can be refined.

No research and development is warranted.

▲ Pineapple

Species

Ananas comosus

Crop Description

Pineapple is a tropical crop with almost all of the Australian production located between Dayboro and the Mary River in SE Queensland.

History of the Crop in Australia

The Australian pineapple industry commenced in Queensland in the mid 1830s with the Smooth Cayenne variety, the current type grown, being introduced in the 1850s. The industry commenced in the area north of Brisbane and this has remained the major centre of production. The past 50 years have seen greatly improved crop husbandry practices and with steady improvements in nutrition, drainage, weed control, and insect control, the Queensland pineapple production has become a highly mechanised and efficient industry.

Current Production in Australia

Appendix Table 5 The area, production and value of pineapples grown in Australia 1988-89 to 1993-94

Year	Area (ha)	Production ('000s tonnes)	Value ($m)
1988-89	6660	154.4	43.2
1989-90	6461	141.6	40.7
1990-91	5927	126.0	37.3
1991-92	5745	133.3	39.0
1992-93	5854	142.4	41.8
1993-94	5870	157.4	45.2

Annually some 70% to 80% of the current production (or about 120,000 tonnes of fruit with the crowns removed) is purchased by The Golden Circle Cannery, Northgate, Brisbane. The balance of production, amounting to about 30,000 tonnes/year, is sold as fresh fruit to retailers and the Brisbane Market with the crowns on.

Nutritional Properties

There are three potentially useful by-products from the pineapple industry.

- Pineapple cannery by-product. Referred to as pulp, this by-product of the juicing process currently amounts to 21,000 tonnes/year wet (2,850 tonnes DM) which is sold under contract to a transport company for disposal, mainly to dairy farmers. Feeding trials by QDPI in 1989 reported:

DM	14.0%
ME	10.3 to 11.3MJ/kg
CP	5.4%

- Pineapple crowns. Also known as pineapple hay, the composition of sun-cured crowns is reported as:

DM	89%
ME	9.2MJ/kg
CP	7.8%

- Crop biomass remaining after last ratoon crop. This is usually ploughed into the soil but has been used as wilted green chop in the feedlot industry. There is only limited information available on the nutritive value, but it is believed to be similar to pineapple crowns. The fresh form has a DM content 26% to 28%, the wilted form some 34%.

Costs

Pineapple cannery by-product (pulp) is being sold for $19.25/tonne fresh within 80km of Brisbane. This equates to a ME cost of $1.27/100MJ, comparing favourably with currently used feedstuffs (Table 3.1).

Current cost of crowns is $20 to $30/bin of 300kg, or $67 to $100/tonne fresh, which equates to a source of ME at $2.42 to $3.62/100MJ.

Farm Production

Pineapples are planted as crowns (more uniform in size than slips) in close rows on a four year cycle, and harvested 18 to 24 months after planting with a ratoon crop 12 to 18 months later. Crops are sprayed with chemicals to induce flowering and facilitate harvesting.

Post Harvest Operations

For the cannery, pineapples have the crowns removed and the fruit transported in bulk bins. The fresh fruit product is sold with crowns on, transported in cartons and, increasingly, in bulk bins.

Most pineapple cannery by-product is produced between February to June and August to September. The by-product is ensiled at dairies or feedlots to even out supply variability.

Feedlot Utilisation

The cannery by-product has been used in Hawaiian and Australian feedlots and dairies since the mid 1950s, and is widely used in Asian feedlots as a reasonable source of energy, when freight is minimal.

SWOT Analysis

Strengths	• The pineapple cannery by-product is a satisfactory source of nutrient energy, reasonably priced. • The pineapple crowns are a medium quality energy source.
Weaknesses	• Pineapple cannery by-product supplies are seasonal and current production is limited. • Low DM content incurs high DM freight costs unless very local source. • Pineapple crowns are a marginal energy source, costly and largely unavailable. • Pineapples are grown in a concentrated area north of Brisbane, with the cannery at Northgate.
Opportunities	• A satisfactory feedstuff energy source where freight is minimal. • There may be potential for utilising the crop biomass remaining after last ratoon crop.
Threats	• Chemical residue from insecticides used on growing crop. • Possibly reduced production in the future, with increasing competition from imported Asian product in processed form.

Likely Constraints to Production

The supply of pineapple cannery by-product is limited by demand for canned fruit and juice which is experiencing strong competition from imported processed product. Crowns are used for planting and are unlikely to become available in quantity and at an economic price.

Use of crop biomass would need to be carefully monitored for residues of the chemicals endosulfan and diazinon which are used for insect control by the pineapple industry.

Conclusion

The pineapple cannery by-product is a reasonable energy source currently used to feed dairy and beef cattle. The supply is limited and seasonal. Crowns are either sold with the fresh fruit or used for planting. As market research has demonstrated consumer unwillingness to purchase fruit with the crowns removed, their supply will remain limited.

There appears to be potential to gather the above ground biomass following harvest of the last ratoon crop. The volume is estimated at 100 tonnes/hectare fresh (27 tonne DM/hectare), or 150,000 tonnes of greenchop annually (37,500 tonnes DM) before allowance for incorporation of some crops into the soil or some areas being too steep to harvest.

Research and Development Needs

As the amount of biomass appears significant, a survey of current pineapple production appears warranted. This survey should determine location and estimate the potential amount of biomass and its cost. The nutritive value of the product should be quantified and the risk of diazinon and endosulfan residues assessed.

Quantities involved are relatively localised, and this would be a low priority for research and development.

▲ Potato

Species

Solanum tuberosum

Crop Description

The potato is the largest of the Australian vegetable industries.

History of Crop in Australia

Potatoes have been grown in Australia since European settlement as one of the community's staple vegetable crops.

Current Production in Australia

Potatoes are grown commercially throughout Australia except in the Northern Territory, with Victoria the largest producer.

Appendix Table 6 The area, production and value of Australian potato production 1991-92 to 1993-94

Year	Area (ha)	Production ('000s tonnes)	Gross Value ($m)
1991-92	40,000	1150	349
1992-93	39,000	1129	317
1993-94	40,000	1185	338

In most areas two crops are grown each year, the main income-earning crop in autumn/winter and the main planting material crop in spring/summer.

Nutritional Properties

The energy feeding value of fresh potato tubers is high, as is their moisture content. A typical composition is:

DM	23%
ME	12.3MJ/kg
CP	9.5%

Costs

The average cost of production of fresh potato tubers is in the order of $250/tonne. The cost of ME is estimated at $8.84/100MJ compared with $2.35/100MJ for wheat at $275/tonne (Table 3.1).

Farm Production

Potato grows best on deep, well-drained loose textured sandy loams with high organic content and pH 5.0 to 6.5. A cool season crop which is susceptible to frost damage, optimum yields are produced at mean ambient temperatures of 15° to 18°C. Tuberisation decreases as soil temperatures increase above 20°C and almost ceases at 29°C.

Vegetatively propagated by seed pieces or setts, weeds are controlled by inter-row cultivation and/or herbicides. The potato is subject to many diseases including blackleg, blights, *Fusarium* rot and leaf roll and many pests such as potato moth, aphids, wireworm and root knot nematode.

The vines are slashed, sprayed with desiccant herbicide or allowed to senesce before mechanically harvesting. Fresh tuber yields of 20 to 30 tonnes/hectare can be expected from each of the two crops/year.

Post Harvest Operations

Potatoes are either graded and/or bagged on the harvester or transported in bulk bins to packing sheds for washing, grading and packing. They can be stored for 10 months at 4° to 10°C and 85% to 90% relative humidity.

Feedlot Utilisation

Only the small, unmarketable tubers, many of which are used for planting material, would be available as stock feed and these, because of their high moisture content, are bulky to transport and an expensive source of ME if freight costs have to be incurred.

Fresh potatoes may be ensiled, after which they are palatable with a feeding value approximately equivalent to corn silage (Ensminger 1990).

SWOT Analysis

Strengths

- A high energy feedstuff commonly used in intensive feeding industries, worldwide.
- Agronomic and management requirements well known.
- Grown in all States.
- High yielding.
- High feeding value and palatable to stock.
- Can be ensiled.

Weaknesses

- As a dedicated crop it is an expensive source of ME.
- Almost all current production is used for human consumption or planting material.
- High moisture content makes transport expensive.
- Vulnerable to many pests and diseases.
- Seasonal availability.

Opportunities

- Industrial by-products do occur and these are highly digestible and palatable to stock.

Threats

- Chemical residues from soil adhering to fresh tubers.
- Consumption of industrial by-products by other stock (eg. pigs).

Likely Constraints to Production

Pests and diseases are probably the only production constraints to the potato crop so well established and in such high demand for human consumption.

The risk of chemical contamination from soil adhering to tubers is a serious constraint associated with using fresh potatoes as stock feed.

Conclusion

High cost, seasonal availability and potential chemical residue problems make potatoes as a specifically grown crop an unlikely major source of ME for feedlot utilisation. However, over 1,000,000 tonnes of potatoes are grown in Australia annually with a probable wastage of 5% to 10%.

There may be some potential in their use as by-products, at particular sites where freight can be minimised.

Research and Development Needs

No research and development warranted.

▲ Lablab

Species

Lablab purpureus

Crop Description

Lablab is a herbaceous perennial frequently grown as an annual throughout the tropics and sub-tropics for forage, grain and the production of green pods. There are numerous varieties, adapted to a wide range of environments.

History of Crop in Australia

Lablab has been widely grown in Queensland where two varieties, Rongai and Highworth, have been developed for forage production. Both are late maturing cultivars likely to be frosted before seeds mature in northern NSW and southern Queensland. Excellent weight gains have been reported from crops grazed by cattle at about flowering. Rongai has brown and Highworth black seed which, although exported, sell at a discount to white seeded varieties.

In 1996, in response to interest in grain production, NSW Agriculture released Koala, the first white seeded cultivar suitable to NSW conditions (flowering 50 to 70 days after sowing). Current studies with white seeded genotypes from CSIRO aim to increase the seed size of Koala which is smaller than preferred for the export market.

Current Production in Australia

Although accurate statistics are unavailable, several thousand hectares would be sown for forage and hay in Queensland and in NSW, small areas for grain production.

Nutritional Properties

Specific nutrient information is unavailable. The grain ME can be assumed to be comparable with other grain legumes at 12.0 to 13.0MJ/kg. Crude protein is 22.0% to 29.0%.

Costs

Unavailable, other than for human consumption where seed attracts $500 to $1,000/tonne.

Farm Production

Lablab is one of the hardiest and most drought resistant of the commonly grown tropical pulse crops, which can be grown on a wide variety of soils. Optimum temperature for growth is 16° to 30°C but it is fairly tolerant of higher temperatures. Some cultivars have limited frost tolerance but cold conditions adversely affect growth, pollination and seed set.

Adequate water is required for establishment with a deep taproot enabling the crop to sustain growth on residual soil moisture.

Lablab establishes readily and for grain production is sown in rows. Fairly early flowering is desirable to prevent rank growth which makes harvesting difficult.

Post-harvest Operations

Lablab makes poor hay or silage unless cut at the very start of flowering. Grain is harvested and handled conventionally.

Feedlot Utilisation

Grain.

SWOT Analysis

Strengths

- Appears to be a high energy feedstuff.
- Easy to establish and grow on a range of soil types in arid and semi-arid tropics.
- Deep rooted and drought resistant.
- Generally pest and disease free.

Weaknesses

- Lack of knowledge on nutrient values, yields, costs of production, and commercial realism.
- Twining growth habit can make harvesting difficult.
- Seed is expensive at $500 to $1000/tonne.

Opportunities

- A tropical sub-tropical grain legume.

Threats

- Value of grain for human consumption threatens feedlot use. Prices currently reported are about $500/tonne for dark seeded cultivars and $1000/tonne for white grain.

Likely Constraints to Production

The major constraint to production of grain or forage for feedlots is the high value of grain for human consumption.

Conclusion

Lablab grain would be a useful, high energy tropical / sub-tropical grain but its current high value for human consumption ($500 to $1000/tonne) eliminates the possibility of feedlot use.

Research and Development Needs

No research and development warranted.

▲ Sugar Beet

Species

Beta vulgaris

Crop Description

Sugar beet is one of the members of the genus *Beta* which includes the vegetables silver beet and beetroot. Sugar beet varieties have been bred and selected for their white fleshy tubers containing high sugar levels.

History of Crop in Australia

First grown in Victoria in 1866, attempts were made to establish a beet sugar industry in the 1870s to 1890s. A factory was opened in 1897 but closed in 1948 after sporadic operation.

The Tasmanian government commissioned research in the 1970s which found sugar beet could not economically compete with most alternative crops under Tasmanian conditions (AIAS 1990).

It was trialed by NSW Department of Agriculture from 1979 to 1981 to assess its potential as a source of fuel and fodder but with the passing of the oil crisis, research work was terminated (Simpson et al 1982).

More recently, Morgan et al (1995) conducted trials on marginal soils in the Burdekin and Mackay sugarcane growing areas.

Current Production in Australia

No known present production.

Nutritional Properties

The feed value of fresh sugar beet tubers is high as is their moisture content. A typical composition is:

DM	20%
ME	13.7MJ/kg
CP	6.8%

Costs

Costs of production are not readily available from experience in Australia. It is generally assumed however that costs would be similar to potato production, and that fresh sugar beet would cost in the order of $200/tonne. This equates to $7.30/100MJ ME indicating sugar beet as an extremely expensive source of ME.

Farm Production

Sugar beet grows on deep fertile soils with pH greater than 5.5, and requires a growing season of 150 days with a moderate summer and cool autumn, and irrigation or frequent rain amounting to at least 50mm/month.

Weed control is a major production cost requiring a high level of management. The crop is subject to diseases (leaf spot, rust and root rots) and pests (aphids and cutworms).

Yields in NSW irrigated trials averaged 44.4 tonnes/hectare of fresh beets, or 12.6 tonnes/ hectare DM (Simpson et al 1982).

Post Harvest Operations

High transport and drying costs would be incurred because of high moisture content. Beets can be fed fresh, or ensiled or dried for longer storage.

Feedlot Utilisation

Unlikely to have a potential due to the high cost of ME.

SWOT Analysis

Strengths

- High yielding.
- High feed value and palatable to stock.
- Salt tolerant and can compete with sugarcane on marginal soils. -

Weaknesses

- Expensive source of ME.
- Limited to cool climates with frequent rainfall.
- High production costs.
- Low dry matter content.
- Vulnerable to a range of root pests and diseases.

Opportunities

- None envisaged in Australia due to costs.

Threats

- Contamination of fresh tubers from chemical residues in soil.

Likely Constraints to Production

The most significant constraints to high production are climatic limitations, the need for high levels of management input, and cost of production.

The risk of chemical contamination from soil adhering to tubers is a serious constraint associated with using sugar beet as a stock feed.

Conclusion

Sugar beet is unlikely to become a competitive source of nutrient energy.

Research and Development Needs

No research and development warranted.

A2.2 Agricultural Origin – Imported

▲ Cassava (Tapioca, Manioc) Pellets

Species

Manihot esculenta

Crop Description

(See also A2.1)

Cassava is grown widely in Asia, principally for stockfeed, and to a lesser extent in the South Pacific Island areas where it is an important component of the population's staple diet. There is a large export trade in processed cassava pellets from Thailand and Indonesia to Europe for use in monograstric and ruminant rations. Thailand exported 7,183,239 tonnes in 1988, of which 5,091,424 tonnes were exported to EEC countries, representing 77.5% of cassava exports. The Asian exporters are equipped with large efficient processing and handling plants and are geared for export.

There is a recently established protocol for the importation of cassava pellets (tapioca pellets) into Australia from Thailand (Appendix 3 AQIS). This protocol was established following a risk assessment undertaken in the early 1990s (AQIS 1990).

It is probable that a protocol for the importation of cassava pellets from South Pacific Island areas, for example Fiji, would be possible. For this to be practical Fiji would need to expand cassava production and establish a pellet processing and handling infrastructure (Wood, personal communications). This should be possible, as the Fiji government is seeking to develop and expand crop exports. It has a policy to concentrate first on its existing indigenous crops (of which cassava is one) with well established production systems.

Nutritional Properties

(See also A2.1)

The product is high in carbohydrate and low in protein, vitamins and minerals, and is a valuable source of ME.

DM	88%
ME	12.8 to 14.5MJ/kg
CP	2.6%

The low protein levels limit cassava as a feedstuff in feedlot rations to the extent that the non-cassava components are able to contribute to the ration's protein requirements. As the cassava component rises, the need for protein supplements increases, eventually increasing overall ration costs.

Following trials on the comparative feeding value of cassava pellets for feedlot cattle, Zinn and De Peters (1991) concluded cassava pellets can replace up to 30% of the DM in growing-finishing diets without adversely affecting ADG or DM intake of feedlot cattle. Marbling score was greatest at 15% inclusion (rather than either

0% or 30%), but the reason for this is not known. Cassava pellets were highly palatable and it was estimated that cassava pellets had 86% the net energy value of steam flaked corn.

Cassava is frequently fed in feedlot rations in Asia at up to 30% of ration DM. Care is needed to maintain a homogeneous mix and avoid separation of the fines, and to obtain adequate protein levels.

Cassava is frequently used in European intensive livestock production systems.

Costs

Commercial interests have indicated that the likely cost for imported cassava pellets from Asia would be approximately $145 to $150/tonne delivered along side ship, bulk, Brisbane or Newcastle basis. Adjusting for DM, and assuming ME at 14.2MJ/kg an estimated likely cost of ME is $1.18/100MJ, which compares favourably with currently used feedstuffs (Table 3.1).

Feedlot Utilisation

(See also A2.1)

Cassava is used in Asia to 30% of feedlot finishing ration components, but usually 15% to 25% on DM basis. It is widely used in European intensive livestock industries.

SWOT Analysis

Strengths

- AQIS advise protocol to import from Thailand in place.
- High energy feedstuff, widely used in Asia and Europe.
- Reasonably costed source of ME.
- Very palatable.
- Can replace up to 30% of DM in growing-finishing rations.

Weaknesses

- Protocols for importation have only recently been developed and no product has yet been imported.
- Low protein, mineral, vitamin levels.
- Maximum practical ration component is 25% to 30% DM.

Opportunities

- Develop a protocol for importing from South Pacific Islands, eg. Fiji, whose supplies may be cheaper.
- Develop production and processing operation in South Pacific Islands. The Fiji government is presently seeking to establish new joint venture operations.
- May be a useful high energy feedstuff in north Australian rations.

Threats

- Currently, supply limitations.

Conclusion

Cassava is also reviewed in Appendix 2.1 as a potential crop for Australian production.

Cassava has only recently been able to be imported from Thailand, and to date this has been of little consequence to the Australian feedlot industry. In the future the South Pacific nations, such as Fiji, appear to offer better prospects for production.

Cassava is a potentially useful source of ME in feedlot rations, in particular in northern Australia, as a part ration component, favourably costed compared with currently used feedstuffs (Table 3.1).

Research and Development Needs

No research and development is warranted except to facilitate the application of the established protocol for Thai imports, and to establish a similar arrangement with Fiji where strong government support could be expected. This is for commercial interests to follow up.

▲ Copra Meal (Coconut Meal)

Species

Cocos nucifera

Crop Description

Copra meal is the by-product of coconut oil extraction from copra, the dried kernel of the coconut. The fallen coconuts are collected by hand, the coconut is split open and the white coconut 'copra' removed by hand. The copra is then dried and transported to the copra mill and sold for oil extraction. Oil is extracted either by organic solvents, or by mechanical expeller presses. The copra is heated to temperatures of at least 120°C during the mechanical extrusion process. Solvent extraction removes greater quantities of oil from the meal compared with mechanical extraction. Most copra mills in the South Pacific use mechanical extraction techniques, and the efficiency of oil extraction varies considerably depending on the extent of wear of the expellers.

The dried meal remaining after the oil has been extracted is termed 'copra meal' (approximately 90% DM), and is suitable for bulk handling and storage. Storage conditions should be dry and cool.

Copra production is an important cash crop for small nations in the South Pacific, including Papua New Guinea, Solomon Islands, Fiji, Vanuatu, Western Samoa and Tahiti. While much of the copra meal has been exported to Europe for inclusion in dairy rations, markets are now developed in Australia and New Zealand. The crop is not grown in Australia (Kempton 1995; Reid, personal communication).

Protocol exists for importing copra meal from South Pacific Islands into Australia (Appendix 3 AQIS).

Nutritional Properties

Copra meal is a source of energy and crude protein for ruminants. A typical composition for the mechanically extracted meal is:

DM	90%	
ME	14.0MJ/kg	
CP	23.0%	(6.0% to 8.0% oil)
	17.0%	(15% oil)

These properties can vary considerably depending on the efficiency of the oil extraction process and crude protein, decreasing with higher residual oil content. At high oil levels storage may become difficult.

Copra meal is highly palatable and is also a general dust suppressant.

The lipid content in the unsaturated fatty acids in copra meal is low and hence when fed to pigs produces a firm body fat. In dairy rations copra meal produces a rather hard (highly saturated) butterfat and at high levels a tallowy butter (Ensminger et al 1990).

The product is generally free of contaminating chemicals.

Costs

Usually in range $200 to $230/tonne delivered alongside ship, bagged, Brisbane or Newcastle basis. Adjusting for DM an estimated likely average cost of ME is $1.71/100MJ which compares marginally favourably with currently used feedstuffs (Table 3.1).

Feedlot Utilisation

Has been used in feedlot rations to 10% of DM primarily as a source of energy in least-cost rations in Australia and Asia.

SWOT Analysis

Strengths

- High energy feedstuff.
- Associated benefits are as a dust depressant and a source of crude protein (70% bypass protein component claimed).
- Produced under a chemical free farming program and hence low contamination risk.
- Very palatable.

Weaknesses

- Marginally competitive as regards cost of ME.
- Variable quality in respect of oil content depending on country of origin.
- Supply often irregular, but improving.
- To date, sporadic demand has meant that product usually supplied in bags rather than in bulk.
- Influence on carcase fat qualities unknown.

Opportunities

- Suitable supplementary ruminant energy source.
- Large firm orders could ensure regular supply and enable bulk handling economies and reduce cost.

Threats

- Problems of availability and regularity of supply may occur, as with any imported product.

Conclusion

Copra meal is a potentially useful source of nutrient energy and supplementary crude protein in feedlot rations, when competitively costed.

Research and Development Needs

No research and development warranted.

▲ Oil Palm Meal

Species

Elaeis guineensis

Crop Description

Oil palm meal is the residue after oil is extracted from the oil palm kernel, principally for domestic use. The meal is produced in large quantities in Asia, particularly Malaysia, Indonesia and Philippines, from where importation into Australia is prohibited.

Protocol exists enabling it to be imported from the South Pacific Islands where supplies are limited, but increasing.

Nutritional Properties

Oil palm meal is a source of nutrient energy and crude protein for ruminants. A typical composition for the mechanically extracted meal is:

DM	90%
ME	12.5MJ/kg
CP	15.0%

The oil from palm kernel produced in the South Pacific Islands is extracted mechanically. While there exists variability in oil and protein content due to source, this is less so than with copra meal.

Produced under a chemical free farming program, the product is generally free of contaminating chemicals.

Costs

Usually in range $135 to $145/tonne delivered alongside ship Brisbane or Newcastle basis, which, after adjusting for DM, equates to a ME cost of $1.24/100MJ, comparing favourably with commonly used feedstuffs (Table 3.1).

Feedlot Utilisation

Oil palm meal has been used in feedlot rations in Asia to 12%, primarily as a source of energy in least-cost rations. It is used widely in European intensive livestock industries.

SWOT Analysis

Strengths	• High energy feedstuff. • Associated benefits are as a dust depressant and source of crude protein. • Produced under a chemical free farming program and hence low contamination risk. • Palatable. • Bulk, regular supply possible under long-term contract on monthly basis, by arrangement.
Weaknesses	• Quality variable in relation to oil content but less so than with copra meal. • Supply limited and irregular, but improving. • Less palatable than copra meal.
Opportunities	• Suitable supplementary nutrient energy source. • Reasonable ME cost.
Threats	• Supply limitations and interruptions.

Conclusions

Palm kernel meal is a potentially useful source of nutrient energy and crude protein in feedlot rations when competitively priced. Supply limitations are a weakness.

Research and Development Needs

No research and development warranted.

A2.3 Industrial Origin – Australia

▲ Fats and Oils

Product Description

Feedstuff fats and oils based on animal and vegetable sources are common by-products of a range of industries.

Nutritional Properties

Fats and oils are energy dense feedstuffs whose composition is typically:

DM	99%
ME	34.0 to 37.0MJ/kg
CP	nil

Generally animal and vegetable fats and oils are closely comparable as feedstuffs. There is considerable evidence that their addition to feedlot finishing rations increases gain and gain efficiency, although results are variable (Huffman et al 1992).

The quality of commercially available fats and oils can vary considerably due to moisture, impurities, unsaponifiable matter and toxic compounds. Fat quality and feeding value for feedlot cattle appear to be closely related and the possible detrimental effects of detracting quality factors are often referred to (Ensminger et al 1990; Zinn 1995).

Bartle et al (1994) found 4.6% of supplemental fat added to sorghum grain based diets improved gain efficiency compared to 1.2%, but did not affect gain. Krehkiel et al (1995) obtained positive benefits in gain efficiency and gain when 4.0% supplemental fat was added to corn-based diets fed to yearling cattle. Zinn (1989) concluded that fat supplementation of a barley-based finishing diet may improve gain efficiency and gain at levels of supplementation as high as 8% of diet DM.

Reviewing the use of supplemental fats to enhance animal performance Brandt (1995) suggested that energy values differ depending on basal diet grain type, environmental conditions (temperature) and other dietary factors. Brandt (1995) concluded that maximum feed usage efficiency in response to level of supplemented fat, translates to approximately 4.0% to 5.0% of diet DM for yearling cattle and total dietary fat not exceeding 650gm daily.

Ensminger et al (1990) recommended supplemental fat be at 2.0% to 5.0% of high concentrate ration DM (where commercially sound).

Clearly, total dietary fat is a necessary consideration in establishing supplemental fat inclusion rates.

Costs

A commercially blended fat (Lot Fat) costs $380 to $420/tonne at source, usually capital cities. An entirely satisfactory blended product based on spent cooking fats and oils is available in limited quantities for usually $80 to $100/tonne less.

At $400/tonne fats and oils have an ME costed at $1.14/100MJ which compares most favourably with current feedstuff sources (Table 3.1).

The cost of fats and oils can be quite volatile in response to changing domestic and international demand/supply levels (Smith, personal communications).

Feedlot Utilisation

Fats and oils are currently used in many Australian feedlot rations based on least cost ration, least cost of gain and maximum return on invested funds principles, but often on a restricted basis. Inclusion rates are frequently suboptimal having regard to the feedstuffs' particular qualities and properties.

Fat is handled in bulk necessitating an appropriate infrastructure on site to receive, store and deliver the commodity to rations.

A satisfactory program of use requires establishment of a routine sampling system by feedyard personnel to monitor and detect impurities, contaminants or toxic compounds.

SWOT Analysis

Strengths

- Very high energy dense feedstuff able to improve ration quality.
- Enhances palatability by improving ration structure.
- Suppresses dust.
- Lubricates feed processing equipment.
- Is easily handled and stored, once suitable infrastructure is established.
- Offers consistent supplies.

Weaknesses

- Risk of impurities, contaminants, toxins.
- Requires specific purpose-designed infrastructure.

	• Upper use level probably 5%. Total dietary fat is a necessary consideration.
	• Requires attention to quality and handling to avoid rancidity.
	• Costs can vary considerably.
	• Requires QA monitoring.
Opportunities	• Energy dense feedstuff at favourable ME cost.
	• Enhances ration quality and feed use efficiency.
	• Can improve ration physical properties.
Threats	• May contain contaminating toxins or chemicals.

Conclusion

Fats and oils are energy dense feedstuffs whose cost frequently make them a most attractive ration component and source of ME. Their inclusion in Australian feedlot rations can almost certainly be extended when competitively costed.

Research and Development Needs

No research and development warranted.

▲ Commercial Food Wastes

Product Description

Commercial food wastes are of a varied nature depending on their source. Sources include such industries as the manufacturers of biscuits, breakfast meals, confectionery, pasta, pastry, bread, jams, fruit juices, beers, and similar products, and vegetable and fruit processors, canneries, and flour mills (Little, personal communications; Branson, personal communications; van der Broek, personal communications).

By their very nature the various food wastes vary greatly in:

- composition
- quality
- quantities
- seasonality and reliability of supply
- purity and degree of contamination.

Much of this waste is unsuitable for use in animal production systems for a range of reasons including contamination with foreign matter such as glass, metal pieces or chemicals. However in 1995-96 an initial investigation within the Sydney region determined that there is likely to be 400,000 to 500,000 tonnes of useable commercial food waste available in NSW, with average 30% DM annually (Appendix 4 UWS; Little, personal communications).

Presumably, much of this would be unacceptable to the feedlot industry for such reasons as:

- unreliable supply and quality
- low DM
- transport and storage difficulties.

However, if it is assumed that 50% is acceptable there would be an estimated 225,000 tonnes of useable food waste available annually, or 75,000 tonnes DM, in NSW alone. The amount would probably be greater in Victoria.

Nutritional Properties

The nutritional properties of food wastes are varied and virtually unknown except for specific products such as brewery and bakery wastes, and the tabulated cannery by-products (citrus, carrots, etc). It is assumed that as the manufactured product components are often largely carbohydrates and oils, much of the waste is a potentially useful source of nutrient energy.

DM content will vary greatly.

Costs

Unknown and unable to be estimated meaningfully until details of the type of waste, the location and the amounts are established.

Feedlot Utilisation

Given better knowledge of the location and availability of suitable wastes and costs, their successful utilisation in a feedlot will then be largely dependent on establishing a mutually attractive transport system, a means of storage and handling, quality control procedures, and an assurance of a relatively regular supply of a largely uniform product.

In developing the transport system there may need to be a facility for collection, depoting, and possibly the drying and blending of components.

SWOT Analysis

Strengths

- Potentially large quantity of high energy feedstuffs at possibly low cost.

Weaknesses

- Lack of knowledge of what, how much, where, and in what form the wastes exist.
- Much of the feed wastes, estimated at 50%, might be unacceptable due to contaminants (physical or chemical).
- Usually sourced in urban and industrial areas.
- Often low DM content.

Opportunities

- Study and define food wastes, their source and characteristics, and determine use.
- Assess quantity and costs of potential feedstuffs.
- If practical and feasible, develop transport, storage and feeding systems utilising feed waste.
- Provide an opportunity to remove current and future environmental problems associated with waste removal.

Threats

- Contaminants, whose risks can be minimised by effective quality control practices.
- High moisture content common and hence freight and storage difficulties.
- Inadequate information on nutritive values.
- Competition for usage from other intensive livestock industries nearer urban fringe (dairy, pigs, etc).

Conclusion

While there appears to be a very large proportion of the food wastes which could be suitable for ultimate inclusion in cattle fattening rations, there is in reality no knowledge of what, where, when and how much is available or of its nature, its supply and consistency pattern.

It appears the majority of these wastes are currently discarded. The exceptions are possibly brewers grains used in dairy and minor cattle feedlot operations, cannery and vegetable processing wastes, and some confectionery wastes used in pig production units. Some wastes are used in fringe urban livestock units, occasionally operating illegally, but much is discarded at a cost.

A study of commercial food industries and their wastes appears warranted to clarify their possible contribution.

Research and Development Needs

A study to identify and establish a data base with respect to commercial food industry wastes outlining and describing:

- their type and nature
- their apparent nutrient values
- their location and source
- their quality
- quantities and seasonality
- possible contaminants
- factors which might exclude a waste as a suitable animal feedstuff
- existing waste handling procedures and costs
- established destinations for wastes.

Initially it is suggested this be on a State basis, for example NSW where a preliminary assessment has been made.

APPENDIX 3
Correspondence: AQIS, January 1997

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File Ref: T96/2255

Mr EJ Sparke
Aquila Agri Business Pty Ltd
Baromee Point
North Arm Cove NSW 2324

29 January, 1997

Dear Mr Sparke ,

Thank you for your enquiry regarding the importation of *cassava* products from Asian countries for use as stockfeeds.

Please be advised that there is an exisiting protocol to bring in tapioca and cassava pellets from Thailand. Applications for tapioca (cassava) pellets from countries other than Thailand may be considered if the country has an equivalent or better disease status than Thailand.

I have attached a copy of the condition for importing tapioca (cassava) pellets from Thailand.

CONDITION:

Each consignment must be accompanied by a certificate signed by a full-time employee of the Office of Commodity Standards, Thai Department of Foreign Trade, or the Sociétie Générale de Surveillance (SGS) Thailand, stating that:

1. the tapioca pellets originate from a plant approved by AQIS.

2. the plant in which the tapioca pellets were processed and stored is registered with the Thai Industrial Standard Institute and meets its quality control specifications.

3. livestock have not had access to the pellets.

4. any surfaces with which the pellets have come in contact during processing and loading have been cleaned prior to use for the consignment of pellets destined for Australia.

5. the conveyances used to transport the pellets have been inspected and found to be clean and there is no evidence that they might have been used for the carriage of livestock.

6. after due enquiry, I have no reason to doubt the statements made in the manufacturer's declaration.

7. a valid Permit to Import has been sighted.

Each consignment must be accompanied by a Manufacturer's Declaration signed by the Manager of the Plant which manufactured the tapioca pellets stating:

1. the date(s) on which the pellets were processed and heat treated to meet the Australian requirements.

2. that the manufacturing plant maintains a permanent record of the heat treatment used to process tapioca pellets. Each consignment must be accompanied by a permanent recording of the heat treatment to which the pellets have been subjected during manufacture (eg direct temperature sensing records), verifying that, at the time the pellets left the pellet press, they had reached a minimum temperature of 90°C.

3. that the heat treatment records accompanying the consignment relate to the processing of the pellets in the consignment.

Each consignment must be accompanied by a certificate signed by the ship's master stating that the ship used to transport the pellets to Australia has not carried livestock within the preceding 12 months.

Each consignment must be accompanied by a phytosanitary certificate signed by an officer of the agricultural regulatory division of the Ministry of Agriculture and Cooperatives certifying that the tapioca pellets had been fumigated in accordance with the requirements as detailed below.

EXPOSED INFESTABLE AGRICULTURAL PRODUCE IN FCL CONTAINERS

All containers with exposed infestable agricultural produce imported into Australia must be unpacked for inspection of the produce and the empty container, unless the following pre-shipment conditions are complied with. These conditions vary in relation to the risk of introducing the serious exotic insect pest of stored produce, khapra beetle (Trogoderma granarium Everts).

Conditions for import also vary in relation to the kind of container used to ship the produce. Fumigation of the empty containers is a requirement where there is a risk of insect infestation as a result of previous cargo carried in the container. Infestable residues often accumulate in spaces behind linings of containers particularly if they have been damaged at any time. These spaces provide favourable habitats for insects to shelter and breed.

Consequently, containers with wall linings must be fumigated prior to loading with exposed infestable agricultural produce. Flat-top, open-sided, insulated containers and those without wall linings do not require fumigation.

EXPOSED INFESTABLE AGRICULTURAL PRODUCE IN FCL CONTAINERS

FCL containers of exposed infestable agricultural produce may be delivered to metropolitan premises at ports of entry registered by AQIS for that purpose.

If a container was carrying more than one kind of agricultural commodity, then FCL delivery would only be permitted to approved quarantine premises in the metropolitan area if the container was packed at one location and is covered by phytosanitary certification for each commodity line in the container.

* CONTAINERS: OPEN-TOP, OPEN-SIDED, INSULATED AND THOSE WITHOUT WALL LINING REQUIRE:

. a packer's certificate indicating the container was unlined, insulated, open-top, open-sided, in sound condition and, prior to loading, was cleaned to achieve freedom from contamination by soil, plant and animal residues and insects; and

. an official international phytosanitary certificate for the agricultural produce immediately prior to loading with the added endorsement that it was free from khapra beetle (Trogoderma granarium Everts) and was grown in the country issuing the certificate.

* CONTAINERS WITH WALL LINING REQUIRE:

. a packer's certificate indicating the container had wall lining in sound condition and prior to loading was cleaned to achieve freedom from contamination by soil, plant and animal - residues and insects;

. official Government certificate of fumigation of the empty container, immediately prior to loading, under a gas-tight sheet with methyl bromide. To ensure effective treatment, correct fumigation procedures must be used (see Appendix V of the AQIS booklet "Cargo Containers - Quarantine aspects and procedures"); and

. official international phytosanitary certificate for the agricultural produce immediately prior to loading with the additional endorsements that it was free from khapra beetle (Trogoderma granarium Everts) and was grown in the country issuing the certificate.

Correctly certified containers and contents may be delivered to approved quarantine premises for unpacking and holding of the goods under quarantine until inspected and cleared by a quarantine officer. The container may be released after unpacking.

Please do not hesitate to contact the officer below if you would like to discuss this matter further.

Yours sincerely

Dr Ann McDonald
A/g Principal Veterinary Officer
Animal Programs Section

Contact Officer: Suzette Burdeu
Ph (06) 271 6404
Fax (06) 273 2097

AQIS
AUSTRALIAN QUARANTINE AND INSPECTION SERVICE
DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

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File Ref: T96/2255

Mr EJ Sparke
Aquila Agri Business Pty Ltd
Baromee Point
North Arm Cove NSW 2324

22 January, 1997

Dear Mr Sparke,

Thank you for your enquiry regarding the importation of *palm kernel expeller* and *copra meal* products from Asian countries for use as stockfeeds. Please be advised that there is an exisiting protocol to bring in *palm kernel expeller* and *copra meal* products from South Pacific Commission countries only.

I have attached a copy of the condition for importing palm kernel expeller and copra meal from South Pacific Commission countries.

CONDITION:

Conditions for the importation of palm kernel expeller, copra meal from member countries of the South Pacific Commission*.

The product must only be imported from the country of origin.

A. For containerised product, bagged and palletised:

1) The product must comply in full with the AQIS container requirements (see "Cargo Containers Quarantine Aspects and Procedures"), including:

a) Government certification that prior to loading the container was clean and free of giant African snail, and

b) Government phytosanitary certificate from the exporting country showing origin of the product, and

2) Manufacturer's certification that the product is pure and contains no other materials, and

3)

a) The consignment is subject to inspection on arrival at a break bulk depot and treatment if necessary, or

EDMUND BARTON BUILDING BARTON ACT
GPO Box 858 Canberra ACT 2601 Tel: (06) 272 3933 Fax: (06) 272 5697

b) Where importers have voluntarily elected to have pre-shipment fumigation of 128g/m3 methyl bromide for 24 hours at 21°C or above at normal atmospheric pressure, correctly certified containers may be permitted FCL delivery with follow up inspection.

B. For containerised product, bulk packed.

1) The product must comply in full with the AQIS container requirements, including:

a) Government certification that prior to loading the container was clean and free of Giant African snail, and

b) Government phytosanitary certificate from the exporting country showing origin of the product, and

2) Manufacturer's certification that the product is pure and contains no other materials, and

3) The consignment is subject to inspection on arrival at a break bulk depot and treatment if necessary.

* This applies to the following South Pacific Commission countries:

American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Northern Marianas Islands, Palau, Papua New Guinea, Pitcairn Island, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna and Western Samoa

Please do not hesitate to contact the officer below if you would like to discuss this matter further.

Yours sincerely

Dr Ann McDonald
A/g Principal Veterinary Officer
Animal Programs Section

Contact Officer: Suzette Burdeu
Ph (06) 271 6404
Fax (06) 273 2097

APPENDIX 4
Correspondence: University of Western Sydney, January 1997

UNIVERSITY OF WESTERN SYDNEY
Hawkesbury

Founded as Hawkesbury Agricultural College 1891

All correspondence to: Student Recruitment
Locked Bag No. 1
Richmond NSW 2753
AUSTRALIA
Tel: 02 9852 4100
Fax: 02 9852 4114

Mr. Jim Sparke
13 Barromee Way
North Arm Cove
NSW. 2324.

Dear Jim,

Please find enclosed information on the utilisation of commercial food waste as an alternative cattle feed, as discussed recently by phone.

The information on the total amounts of commercial food waste in N.S.W that I have included here are extrapolated estimates based on the 30 companies surveyed in Sydney last year.

I hope I have included everything you expected. If there is anything else you need to know please give me a call. My numbers are:

PHONE: (045) 701 897 - Work-
(047) 210033 - Home
FAX: (045) 701 383 - Work
E-MAIL: s.little@pnc.com.au

Yours Sincerely

Simon Little.

PRELIMINARY RESULTS

OF AN INITIAL STUDY ON

THE ESTIMATED AVAILABILITY OF

COMMERCIAL FOOD WASTE IN

NEW SOUTH WALES

COMMERCIAL FOOD WASTE AVAILABILITY IN NEW SOUTH WALES

In 1995/96 I was involved in sourcing high energy food waste from commercial sources with the view to produce alternative feed sources for pigs. This work was prompted after a meeting with Greg Roese from the Department of Agriculture, NSW who is heavily involved with this research.

My initial investigation involved 30 major food producers within the Sydney region. These companies included confectioners, pasta and pastry producers, jam and fruit processors and fruit juice manufacturers.

The total waste per month produced by these 30 companies was approximately 15,000 tonnes. This figure is quite variable however due to the following factors:

1. *Seasonal Variation*: Many food products are produced on a seasonal basis or produced in larger quantities in certain seasons where demands are higher.
2. *Quality*: Some of the waste product cannot be used due to contamination with glass, chemicals or other foreign matter.
3. *Self-utilisation of Commercial Food Waste*: Many companies are starting to realise the importance of their waste products and although many companies are willing to sell this waste in its current state, many other companies are studying ways to incorporate their waste back into consumer products to increase profit margins.

Taking all these factors into consideration, from initial studies it appeared that at least half this monthly tonnage could be relied upon.

With over 250 companies in New South Wales (100 in Sydney) not included in this study there is likely to be approximately 400-500,000 tonnes of useable food waste per year. These figures are based on initial studies that approximately 50% of companies are already utilising their waste to some degree. ***This figure is however an educated estimate*** and it is ***possible that the amount could be considerably higher***. It is doubtful that it would be any lower.

PRESENT DISPOSAL METHODS OF AVAILABLE FOOD WASTE

There are 2 major disposal methods for food waste that companies appear to be making use of. These became apparent during the study conducted in 1995/96.

1. ***Contractual relationships with Waste Disposal Companies.***

Approximately 25% of companies are presently paying to have their waste removed. This can naturally be a costly exercise, but is also often seen as essential as keeping food waste on company premises for extended periods of time can result in microbiological and rodent problems.

From various discussions it was made clear to me that many of these companies are *very willing to co-operate* and become involved in a project such as this. Naturally so, as in this case they would still fulfil their main objective of having their waste removed and also receive remuneration.

2. ***Ineffective , intermittent disposal to local farmers.***

Some companies have already looked into ways of disposing their waste without paying for it. The most common scenario is the local cattle or pig breeder that turns up whenever he feels like it and even then may decide not to take the waste if it looks different to the last load he collected. Some companies are charging local farmers a small fee for the waste product, while others are not.

This is not proving an effective method of waste removal for the companies involved. From discussions with these companies it appears that they would be extremely interested in finding a buyer for their waste product that is consistent, reliable and prepared to collect the waste regardless.

FACTORS TO CONSIDER IN DEVELOPING PROJECT

There are some extremely important factors that need to be taken into consideration when developing a project of this type. Below is a list of 7 parameters that need to be built into this study if it is to have any merit. This list is by no means exhausted and further discussions will lead to more factors being identified.

1. ***Amount of food waste available in N.S.W:***

The first stage of this project is to screen all food companies in New South Wales to determine the overall quantity of food waste produced per year. It is recommended to do this by telephone or personal visit to the factory, as questionaries sent to company premises are often never answered.

2. ***Quality of the food waste:***

It is imperative that a thorough knowledge of the processing steps used by each company is known as this will give indications as to whether the food waste from a certain company is likely to contain glass or not. It is recommended that any company that uses glass jars in the filling of their product/s not be included in the study unless that waste can be guaranteed to be free of glass.

A similar strategy should be put in place to monitor the likelihood of chemical contamination occurring in any food waste that is to be considered as an animal feed.

3. ***Compositional Variation:***

Although not always feasible, it should be kept in mind that the food waste from any of the companies involved in the project should be reasonably consistent with regards to composition. It is possible that animals may exhibit unwanted side-effects from being fed a constantly changing diet.

4. ***Nutritional Value:***

This will prove to be one of the major factors involved in this project, as it is essential to have a nutritional breakdown of the food waste being collected from different sites to determine what type of mix would best suit the animal's nutritional requirements.

This will involve the determination of:

A. Energy levels (Kilojoules / Kg)

B. Protein

C. Fat

D. Vitamin (profile)

E. Mineral (profile)

F. Solids (%)

G. Inorganics

Others etc.

5. ***Method of Excess Moisture Removal:***

It will be important to determine moisture levels from the nutritional profile of the food waste. From discussions with many companies it appears that food waste often has a considerably high water content, sometimes as high as 90%. This obviously means that if it is not intended to incorporate liquid feed into the diet (as is being currently studied within the pig industry) then it would be essential to remove this water to obtain the remaining solids.

It will be necessary to incorporate a drying method in the preparation of food waste with a moisture content greater than 30-50%.

Another reason for the evaporation, is the added and needless cost of transporting water. Obviously the waste product would have to be picked up in an "as is" state from the manufacturer, but it could then be taken to a central evaporation site to remove excess water. This would then save on transportation costs to the next destination (such as a distribution site).

Alternatively, it may prove more feasible in the short term to avoid all food waste with a moisture content of 50% and greater, although this would reduce the source numbers considerably

6. ***Method of Incorporation into Stock Feed:***

Firstly it would be necessary to determine whether the food waste would be used as a supplement to existing rations or whether it would become a staple diet.

If it is to be used as a sole food source then it would be necessary to determine the physical state in which it would be fed. If it is to become a supplement then it would be necessary to *also* determine the optimum addition rates to the existing food source.

7. ***"Pick-up" and Distribution:***

As important as any of the other parameters already discussed, the transportation of the food waste will determine the feasibility of the whole project and definitely influence the price paid by the cattle farmers for whom this project is partly aimed at helping.

Once co-operation between companies and project co-ordinators is evident then it would become necessary to determine a central location to receive the food waste and to make any necessary changes to the product. Then it may prove feasible to have another location that is central to various farming districts from which the food waste could be distributed more effectively.

APPENDIX 5
Terms of Reference

ALTERNATIVE ENERGY DENSE FEEDSTUFFS FOR THE CATTLE FEEDLOT INDUSTRY - PHASE 1

TERMS OF REFERENCE

THE CONSULTANCY SERVICES

BACKGROUND

The business plan for the Feedlot Consistency and Sustainability Key Program (FCSKP) has identified a likely increase in the real price of energy dense feedstuffs, and the security of its supply, as a core problem affecting the long term prosperity of the cattle feedlot industry ('the Industry') in Australia. The increase in the price of energy dense feedstuffs in the medium to long term will be driven by global feedgrain supply and demand. Notwithstanding the generally lower feedlot-gate price of feedgrains in Australia (cf USA by default of higher farm-to-market transport costs), it is postulated that in Australia a more competitive unit cost, and security of supply, of energy dense cattle feedstuffs could be achieved from new purpose-grown alternative crops or, by better use of existing energy dense by-products.

The Meat Research Corporation ('the Corporation') intends to initiate a new R&D project to evaluate the above proposition and, if feasible, help to stimulate the establishment of commercial supply of alternative energy dense feedstuffs. A 3-phased project is envisaged, comprising:

Phase 1 A review and preliminary feasibility study of alternative crop and by-product options;

Phase 2 Specific technical research into issues and constraints identified in the first phase and;

Phase 3 Catalysing commercial development.

The Terms of Reference hereunder relate to Phase 1 of this R&D stream.

OBJECTIVE

The objective of Phase 1 is to review past research and commercial experience in Australia and overseas and on the basis of this: (a) determine if it is feasible for potential feedstuff suppliers to profitably grow new crops, or better exploit by-product of existing crops, by which the cattle feedlot industry can be supplied with lower cost metabolisable energy than from traditional feedgrains in the medium to long term, and (b) identify any specific areas for R&D which may be required to unlock significant new supplies of high energy feedstuffs from commercial planting of alternative crops and/or better use of byproducts.

REQUIREMENTS UNDER THE CONSULTANCY

Scope

The scope of the work will be wide reaching and comprehensive in terms of potential crops considered in the first instance but, in particular, would address the opportunities offered by cassava, sugar beet and better use of cotton industry by-products. For the more promising alternative crops initially identified , the technical, environmental, legislative and financial feasibility of establishing commercial production, and if necessary processing, of each crop to supply alternative energy dense feedstuffs will be evaluated. The scope of the work will include, but not necessarily be limited to, the following:

- ☐ identification of alternative crop options in sub tropical and temperate Australia for producing energy dense feedstuffs suitable for intensive cattle feeding;
- ☐ assessment of the present availability of planting material of suitable cultivars in Australia and/or the constraints to the importation of start-up planting material from overseas;
- ☐ identification of existing crop by-products (excluding by-products of sugar production which are considered as a separate R&D initiative) which are under-utilised and which are a price competitive source of metabolisable energy;
- ☐ establishment of the edapho-climatic limits to the identified crop species and cultivars;
- ☐ description of the crop agronomy and sustainable production systems which are most appropriate for Australia farming methods and specific on-farm inputs requirement (e.g. for planting, harvesting, pre-processing and storage);
- ☐ identification of specific processing requirements to convert the energy dense farm product to a feedstuff input suitable for use in the cattle feedlot industry;
- ☐ description of the nutritional properties of feedstuff products derived from alternative crops and a literature review of nutritional limits for cattle and an assessment of the least cost ration formulation which could be achieved with the new feedstuff and its impact on meat quality and animal health;
- ☐ a preliminary analysis of the potential on-farm net returns for the grower of alternative energy dense feedstuff crops compared with presently grown crops, sensitivity tested for a

range of yields and product prices and estimation of the threshold price and yield required for farmers to be attracted to changing to production of such a new crop;

- where off-farm processing of a feedstuff is required, an evaluation of the capital and operating cost of establishing and operating such a facility and an estimation of optimum throughput requirements and area under crop needed to achieve viability of the processing operation;

- determination of the present feedlot capacity which could be beneficially supplied from the potential production area of alternative energy dense feedstuff crops; and

- identify and comment on any other potential constraint (e.g. environmental, crop residue, and legislative) which might constrain the growing of alternative energy dense feedstuffs in Australia.

Methodology

Phase 1 will be a desk study involving, (a) a review of the scientific literature, particularly in relation to nutritional properties of feedstuff, (b) consultation, as far as commercial-in-confidence constraints permit, with commercial operators with previous experience and expertise (e.g. Cassava growing by Goodman Fielder in Queensland in early 1980s, CSR, who investigated the role of cassava for ethanol production, AMH who investigated the importation and feeding of tapioca hard pellets, and overseas manufacturers of processing plant and equipment), (c) consultation with researchers and advisors with past direct experience with these crops, (d) a review of old Government departmental reports and, where permitted, unpublished files of past initiatives. The study will require an analysis of regional cropping statistics, climatic data and a capacity to interpret and extrapolate potential crops areas from existing soil maps. Farm models will be developed to analyse the potential net returns and break-even yields and prices, to demarcate the present feedlot capacity which could be economically supplied by new energy dense feedstuffs and, to establish optimum sizing of any processing component.

Output

The output of the research will be a Report which will be presented, in the first instance, as a Draft Final Report for the consideration and comments of the Corporation and the FCSKP Consultative Group. The Final Report will be revised to address comments made on the Draft Final Report and re-presented to the Corporation. The report will contain an Executive Summary which will, as far as possible, read as a stand alone document which effectively summarises the full document in a form suitable for Industry. The report will indicate if specific Phase 2 R&D is required and Terms of Reference for the such Phase 2 components. A list of contacts interviewed during the course of the research will be appended. If the Consultant has access to commercial-in-confidence data, germane to the study outcome, the MRC would not require this to be presented in the Report nor sources identified. Subject to agreement between the parties involved, such commercial-in-confidence data may be presented in an unpublished, Part 2 document.

Six bound copies of the Draft Final and Final Reports will be provided to the Corporation as well as a disk copy of the Final Report using agreed software.

Consultative Group

This project is a component of the MRC's FCSKP which has a Consultative Group of Industry representatives. The outcome of this project will be referred to this group for endorsement prior to acceptance of the Final Report.

Access to Information

Where information is available which may assist the Consultant in meeting the requirements of this research, such information will be provided to the Consultant on a confidential, or other basis as indicated, by the Corporation and members of the FCSKP Consultative Group. Confidential information would not be reproduced in the report; consistent with the caveats mentioned under 'Output'.

Timing

The Corporation is anticipating that a contract with the Consultant to proceed with the Phase 1 Review and Feasibility Study will be finalised by 27 September. An elapse time of 3 months to complete the Report is envisaged with the Final Report of the Phase 1 Review and Feasibility Study being delivered to the Corporation by 20 December, 1996. Within the first fortnight of the Study, the Consultants will deliver a brief Inception Report in which suggestions (if any) on fine tuning of the Study scope and potential outcomes will be presented for consideration by the Corporation and FCSKP Consultative Group.

Costing

The Corporation seeks a quotation for the full Phase 1 review to be carried out under these Terms of Reference. The details of costing provided to the Corporation will include professional fees, calculated on a daily rate for each person, or party involved, and will cover professional services of the Consultant, provision of office facilities, electricity, local telephone/facsimile calls, postage, clerical/secretarial services and indirect costs (overheads). Out-of-pocket expenses will be reimbursed at cost for travel and accommodation, long distance telephone/facsimile and external costs of report preparation.

Progress payments will be made by the Corporation against completion of the components of the review identified with milestones agreed to by the Corporation. Final payment by the Corporation will be subject to written acceptance of the Report by the Corporation. All payments will be subject to receipt of invoices from the Consultant.

Subcontracting

Certain activities and analysis may be subcontracted by the Consultant to other parties. In this case full details of the party or parties to be sub-contracted, their capabilities and background and the activities or analysis which they would perform in the context of this review will also be provided to the Corporation Notwithstanding this, the responsibility for the performance of the sub-contractor will rest completely with the prime Consultant with whom the MRC would be contracted.

Reporting and Liaison

The consultant shall report to the Corporation through Mr. David Skerman. Apart from an Inception Report at the end of the first fortnight, the Consultant will provide a brief statement of progress (by letter or facsimile) at the end of each fortnight.

Industry Presentations

The Consultant will be available to give presentations on the conclusion of the Review at up to three industry meetings, if so invited by the Corporation. The costing of such presentations will be separately identified within the Consultancy Agreement.

Confidentiality

The Consultant may divulge that the Review is being undertaken at the request of the Corporation. Otherwise the specification of the Review, contents and conclusions of the Review and the Report produced are strictly confidential. The Consultant may not disclose any details or information in respect of the Review to any party without prior written consent of the Corporation.