Australian Oilseed Federation

Canola Meal

Limitations and Opportunities

September 2004

Prepared by Dr Rodney Mailer

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Now incorporating NSW Agriculture
ABN 51 73 412 4190-004

Contents

1. Executive Summary

This survey has been undertaken for the Australian Oilseed Federation to identify limitations to the quality and utilisation of canola meal produced in Australia. In doing so, members from all phases of the industry have been interviewed including breeders, chemists and managers of crushing plants, grain-traders, nutritionists, researchers and consultants. They included people from the pig, dairy, beef, poultry, aquaculture and pet food industries.

The desired output of the activity was to provide a list of priorities or areas for further work with an indicated scope of the work required. This could include actions such as changed breeding priorities, feeding trials, modified processing methods and extension activities.

Feedback from the industry identified several factors in regard to canola meal which might reasonably limit the use of the meal or reduce its competitiveness with other products. Comments from various parts of the industry identified problems with parameters specific to their personal requirements such as sinapine for the poultry industry or by-pass protein for ruminants. However, there were some common factors across all phases of the industry such as inconsistency in the product or heat damage during processing.

Although many of the limitations identified were based on real evidence and productivity of stock using the meal, some factors were based on perceptions about the product and even quality factors related to rapeseed which are not significant in new cultivars of canola. For example, the influence of erucic acid, at 0.1% of the total fatty acids, in meal with only 8% total oil, would be unlikely to produce any negative effects.

A list of recommendations, or priorities, is provided at the end of the report. They include the problem, who might address the issue and what the outcome should be. Recommendations are based on possible opportunities to improve the value of the product to the industry. In some cases it would appear that they are simple tasks with high probabilities of success. However, in others it may be difficult or not financially viable to change the current situation. These decisions need to be discussed and decided on by the experts in those fields.

2. Acknowledgements

A number of people provided expert and specialty advice on these topics and some extended considerable time to allow the information to be gathered. These included members of the NSW Department of Primary Industries, Cargill and Riverland Oilseeds. Some results from the Grains Research and Development Corporation research trials have been utilised. The list of participants who contributed is presented in the Appendices.

3. Aims

The aims of this project have been to develop a better recognition of the value of canola meal in stockfeed rations, based on the actual quality out-turned by crushing plants. This has involved a practical exercise of benchmarking quality of Australian meal produced against theoretical values.

The intent was to review the needs of end users in relation to deficiencies in canola meal, and to identify strategies to improve meal quality and utilisation with an economic value to both end users and the oilseed industry.

Basically, it has been the aim to help to set priorities for a more substantive investment into protein meal and to identify possible sources of funding for research or development. The survey attempts to determine the best method for quality improvement utilising different levels of the industry including refining, processing, bulk handling or plant breeding.

Ultimately, the project aims to improve the value of canola meal for end users and increase returns to all levels of the industry.

The output of this activity will be a list of priorities or areas for further work with an indicated scope of the work required. This may include actions such as changed breeding priorities, feeding trials, modified processing methods and extension activities.

4. Approach

The elements of the approach in developing this report include:

- A limited literature review of past research projects to identify specific needs and deficiencies for those industries.
- A qualitative industry survey of all phases of the industry including dairy, pigs, poultry and fisheries industries to obtain first hand information from the industry regarding trends in canola meal usage, limitations to use and potential for increased usage with product improvement.
- Benchmarking of Australian canola by comparing canola quality results from crushers with that expected from theoretical levels shown in the literature.
- Identification of current meal quality, including attributes as well as negative aspects such as antinutritional components from literature values and laboratory analysis including fibre, sinapine and glucosinolates.
- Prioritisation of the issues that require attention in terms of importance to the industry.
- Identification of possible approaches to overcoming limitations for the consideration of the industry with the aim of improving demand for the product.

5. Background

5.1 Canola

Canola includes seed from *Brassica napus* and *B. rapa* with low levels of glucosinolates in the meal and a low concentration of erucic acid as described by the Canola Council of Canada. Canola meal, or flour, is the by-product of the seed after oil has been extracted either physically or by solvent extraction. Canola seed must conform to the Trading Standards listed in the Australian Oilseed Federation's "Quality and Trading Standards" which describe moisture, oil content, crude protein and fibre, seed damage and admixture (Table 1). The meal, in particular, must contain less than 30 µmols /g of aliphatic glucosinolate in the oil-free meal (Canola Council of Canada).

Table 1. Current Australia Trading Standards for Canola Meal

Component	Limit	
	Solvent	Pressed
Oil content (minimum %)	0.5	4
Moisture content (maximum %)	12	11
Glucosinolates (µmoles / g in oil-free meal)	<30	<30
Crude Protein content (minimum %)	34	32
Crude Fibre (maximum %)	15	14

Source: AOF Trading Standards 2003

5.2 Canola Meal Processing

The process of separating oil from canola seed involves several steps. The by-product, referred to as the meal or flour component, is utilised for stockfeed. Although the initial physical extraction of oil from the meal is common to all crushing plants, there are alternatives to processing to reach the final product. These include:

- Cold-pressed – where the oil and meal is physically separated without heat
- Expeller - where the oil and meal is physically extracted with added heat
- Solvent extracted - where the oil and meal is extracted with the combined physical "expeller" extraction followed by solvent washing

The solvent extraction method results in more efficient extraction of the oil and produces a meal with less than 1% oil residue. Expeller and solvent extraction use different amounts of heat which may alter characteristics in the meal. Cold-pressed and expeller meals can contain 8-12% oil and are processed generally at moderate temperatures of <60°C although this can be considerably higher. Each method of extraction results in slightly different characteristics in the meal. Glucosinolates and their volatile by-products would normally be lower in heat treated and solvent extracted meal.

The steps in the solvent extraction process are:

i) Flaking

Initially the seed is preheated and then passed through roller mills at about 35°C to break the seed. This "flaking" operation ruptures cells walls and reduces the seed to flakes without damage to the oil. The flakes are cooked at 80-105°C for 15-20 minutes to complete cell breakdown and to reduce the viscosity of the oil. This also provides the opportunity for endogenous myrosinase enzyme to be hydrolysed and thus prevent breakdown of glucosinolates in the meal to undesirable products which would affect the quality of the oil and meal. The moisture content of around 10% is critical to the hydrolysis of this enzyme and the temperature must be raised quickly to around 90°C.

ii) Extraction

a. *Physical extraction*: Flaked canola is passed through a continuous screw press to remove around 60% of the oil. Excessive pressure and temperature need to be avoided to prevent damage to the product. Generally the temperature does not exceed 105°C although in some cases it may reach 130°C.
b. *Solvent Extraction*: Solvent extraction is used to remove the residue of oil which constitutes around 20% of the cake. The solvent is generally hexane and is recovered for re-use following separation of the oil from the meal. The meal at this stage is virtually free of oil and is referred to as "marc".

iii) Desolventizing-Toasting (D/T)

The marc is removed to a desolventizer-toaster. The residue of the solvent is removed by the use of steam and the meal is finally dried for about 20 minutes at around 105°C. The final product is solvent free and contains about 10% moisture and less than 1% oil.

iv) Additives

After the D/T operation, some of the by-products of solvent extraction, including gums and soap stocks, may be remixed with the meal, theoretically increasing the meal quality and energy value. This also has the effect of increasing the oil content and darkening the colour of the meal.

v) Heat Treatment

The heat treatment used throughout the solvent extraction process is important for the breakdown of myrosinase enzyme which would otherwise release the hydrolysis products of glucosinolates, particularly sulphur, into the oil and other toxic substances into the meal. Glucosinolate hydrolysis results in the release of volatile isothiocyanates with strong sulphur odours. The concentration of glucosinolate in the meal is generally significantly less after oil extraction. High temperatures during processing however will result in reduction in protein quality, particularly available lysine. The main damage to protein amino acids occurs during the D/T phase at which lysine content and protein digestibility are reduced. Colour change also occurs during toasting with lower temperatures favouring a lighter coloured meal, which is preferable in many cases for feed manufacturers.

5.3 Quality Characteristics of Canola Meal

Canola is a mid protein meal with a good amino acid profile and mid range fibre content (Tables 2 and 3). It is generally felt that the by-pass protein of canola is better for ruminants although some nutritional consultants consider that it lacks in rumen degradable protein. It is possible to get good results for canola in terms of livestock performance when utilised to maximum value. This requires a good knowledge of the product. The information on out-turn quality is limited as crushers generally only measure those components they consider are variables they can control. These include moisture, crude protein and oil content. The variability in the seed quality over successive years and different environments adds to the meal inconsistencies. Table 4 includes data on canola seed analysis from bulk handling authorities and from NSW Agriculture for grain received by bulk handlers in 2003/04. The range in oil, protein and fibre contents illustrates the environmental variation that exists. Processing conditions may further influence the range in the final quality of these parameters.

Table 2. Canola Meal Nutrient Composition Tables

Component	Canola Meal		Soybean Meal
	Canada[a]	Australia[b]	USA[c]
Moisture (%)	10.0	10.0	12.0
Crude protein (N x 6.25;%)	35.0	*37.0*[d]	47.0
Rumen bypass protein (%)	35.0	-	
Oil (%)	3.5	2.9	
Linoleic acid (%)	0.6	*0.58*[d]	
Ash (%)	6.1	-	6.02
Sugars (%)	8.0	-	9.17
Starch (%)	5.2	-	5.46
Cellulose (%)	4.6	-	
Oligosaccharides	2.3	-	
Non-starch polysaccharides (%)	16.1	-	
Soluble NSP's (%)	1.4	-	
Insoluble NSP's (%)	14.7	-	
Crude fibre (%)	12.0	*11.9*[d]	5.4
Acid detergent fibre (%)	17.2	*16.9*[d]	7.05
Neutral detergent fibre (%)	21.2	*26.6**	11.79
Total dietary fibre (%)	33.0	-	
Tannins (%)	1.5	-	
Sinapine (%)	1.0	1.5	Nil
Phytic acid (%)	4.0	-	
Glucosinolates (μmoles/g)	16	11	Nil
Bulk Density, mash	16 kg/ft^3, 565 kg/m^3	-	
Bulk Density, pellets	19 kg/ft^3, 670 kg/m^3	-	

Source[a]: Canola Council of Canada - Feed Industry Guide; [b]: Perez-Maldonado 2003; [c] - American Soybean Association; [d] - NSW DPI.

Table 3. Amino acid composition of canola meal

Amino Acid	Canola Meal Canada[a]	Canola Meal Australia[b]	Soybean Meal USA[c]
Alanine	1.53	1.49	2.05
Arginine	2.12	2.33	3.48
Aspartate	2.55	2.53	5.49
Cystine	0.94	0.91	0.73
Glutamate	6.43	6.79	8.62
Glycine	1.75	1.75	1.97
Histidine	1.13	0.84	1.21
Isoleucine	1.41	1.38	2.17
Leucine	2.39	2.48	3.60
Lysine	2.02	1.9	2.89
Methionine	0.77	0.50	0.63
Methionine + cystine	1.71	1.41	1.36
Phenylalanine	1.54	1.45	2.37
Proline	2.23	2.70	2.37
Serine	1.64	1.60	2.38
Threonine	1.50	1.50	1.84
Tryptophan	0.46	0.50	0.63
Tyrosine	1.05	-	1.68
Valine	1.71	-	2.30

Source[a]: Canola Council of Canada - Feed Industry Guide; [b]: Perez-Maldonado 2003; [c] - American Soybean Assoc.

The key quality issues for end users are:

i) Crude protein level and moisture content

Protein and moisture are the main factors on which canola meal quality is based and are the parameters on which meal is traded. However, for most applications the “true protein versus the available protein” is a more critical factor. Available protein is seldom determined other than in research studies and figures used in formulations are generally based on theoretical values.

The standard for canola meal moisture is 11% or 12%, expeller or solvent extracted respectively (Table 1), and thus, meal generally trades at these levels. Lower moisture levels may assist to reduce the risk of microbiological activity and higher moisture content results in a diluted meal value. This is a price/quality issue that needs to be discussed between suppliers and customers.

Table 4. Australian canola seed quality

	Glucosinolates µmoles/g whole seed 6% moisture	Oil % in seed 6% moisture	Protein % 10% moisture	Sinapine g/kg as is	Neutral Detergent Fibre (% - as is)	Acid Detergent Fibre (% - as is)	Crude Fibre (% - as is)
Min.	5	33.5	35.6	9.1	20.3	13.6	8.8
Mean	10	41.5	39.2	12.0	26.6	16.9	11.9
Max.	14	46.0	44.6	15.5	31.1	23.2	16.7

Based on samples from Bulk Handling companies in 2004, published in “Quality of Australian Canola 2003”.

ii) Measuring the real value of meal

Although some feed manufacturers have reasonably sophisticated laboratories, the ability to rapidly measure digestible and available protein, amino acids, vitamins and minerals is not available due to time and cost restraints. As a result, formulations are often based on minimum quality levels or theoretical values. For example, protein meal which varies from 34 to 38% protein would be costed at 34% protein to minimise risk. Thereby the necessary protein requirements in some rations are exceeded and the value of the canola meal is underestimated.

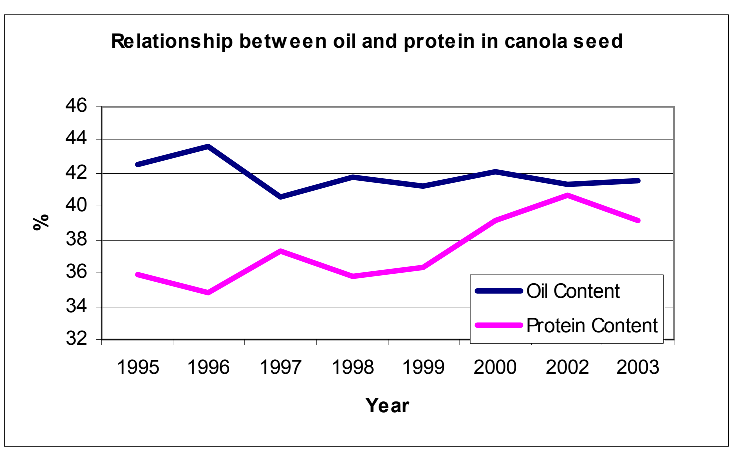
iii) Consistency

Lack of consistency in meal quality, particularly protein, is a major problem for end users. This is a factor of both environmental conditions and processing.

Figure 1 illustrates the average oil and protein concentration of canola meal from Australian crops over the last eight years. Although oil concentration appears to be consistent at 42%, Table 4 shows that it actually varies from 34 to 46%. Much of the variability is removed during seed handling between farmers seed and solvent extracted meal, but the variation may be state or region based, depending on environmental conditions. Similarly, protein figures show a gradual increase from 35 to 40% on average (Fig. 1) but again Table 4 indicates the range may be from 36 to 45% on delivered grain. These problems with consistency were identified as limitations by several sectors of the industry and need to be addressed by bulk handlers and meal suppliers.

Expeller meal was said to range from 8-15% fat and variations in cooking conditions between processors resulted in a range of amino acid availability. Expeller processing temperatures may vary from 95 to 130°C resulting in large variations in protein quality.

Fig 1. The relationship between oil and protein in canola seed

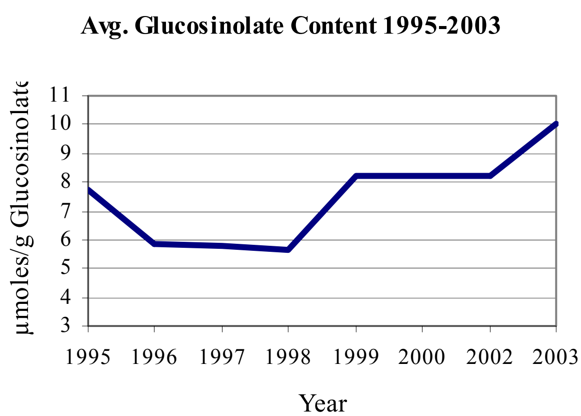


iv) Glucosinolates

It is recognised that glucosinolate levels in canola are not a reason for capping the amount of meal used, as was the case for rapeseed. Many participants however, when questioned, immediately responded to the presence of glucosinolates and erucic acid in canola. These seem to be perceptions that there are problems with canola, presumably based on rapeseed meal from the past. There did not seem to be any real evidence that glucosinolates were actually causing a problem. However, the perception remains and when problems are incurred, canola tends to be the primary suspect. There is a feeling that the development of canola cultivars with zero glucosinolates may encourage an increase in canola meal usage in some industries.

Despite this, glucosinolates are of particular interest given recent trends that have been observed. Studies have shown that glucosinolate concentrations increase under water stress. This may account for the pattern identified in Figure 2 which shows glucosinolates have been increasing over the drier years of 2002 and 2003. This influence of the environment enhances the need for breeders to be vigilant about glucosinolate concentration in the selection criteria for new cultivars with an aim to reduce them to insignificant levels or possibly to zero. Table 5 illustrates the variation in glucosinolate concentration within and between cultivars and over variable environmental conditions.

Fig 2. Glucosinolate content in Australian canola seed (6% moisture)



A glucosinolate concentration of 17 µmol/g in seed at 42% oil is equivalent to 30 µmols/g oil-free meal.

iv) Fibre content

Little work has been done on fibre levels in Australian canola and no direct selection pressures has been applied in breeding programs to reduce fibre. Table 5 indicates the variation that can occur for ADF fibre over a range of environments. Additionally, the data indicates that there is a significant relationship between fibre content and the protein concentration (Fig 3). It would appear that a breeding aim to reduce fibre may be beneficial to increase oil and protein content in canola seed and improve nutritive value.

The ratios of ADF, NDF and crude protein are obviously important in formulating stockfeed diets and this data needs to be more readily accessible for the Australian end-users.

Figure 3 Relationship between acid detergent fibre and protein concentration in canola meal

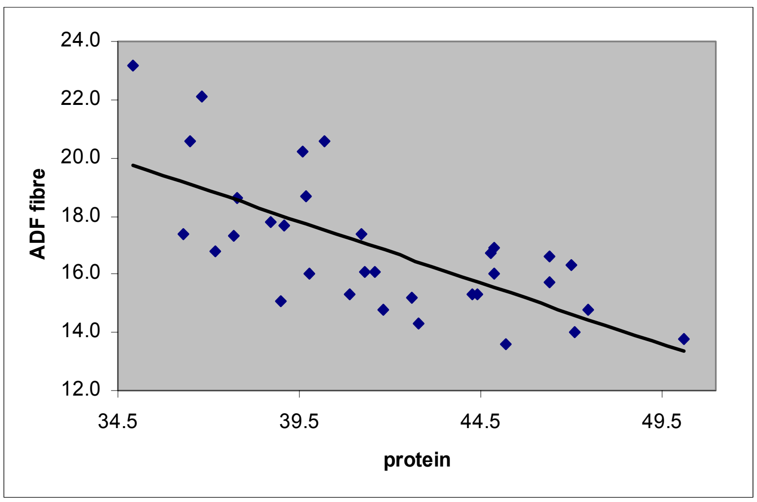


Table 5. Oil, glucosinolate, crude protein and fibre values for selected Australian cultivars in 2004

			Oil (%)	Crude Protein (%)	Glucosinolate µmoles/g	Crude Fibre % (as is)	NDF % (as is)	ADF % (as is)
NSW	*Wagga Wagga*	Mystic	37.6	40.9	7.0	10.1	23.1	15.3
NSW	*Moree Livingston*	Mystic	37.8	46.4	11.0	10.3	27.6	15.7
VIC	*Walpeup*	Mystic	38.3	44.9	8.0	12.1	30.2	16.0
SA	*Minnipa*	Mystic	38.8	44.3	10.0	12.2	23.1	15.3
VIC	*Horsham*	Mystic	40.1	39.1	11.0	10.8	28.5	17.7
WA	*Newdegate*	Mystic	40.7	41.2	10.0	13.0	28.8	17.4
VIC	*Beulah*	Mystic	43.1	39.8	8.0	13.1	25.0	16.0
SA	*Lameroo*	Mystic	43.3	37.2	11.0	13.7	27.0	16.8
WA	*Wongan Hills*	Mystic	47.6	36.5	6.0	13.8	28.3	20.6
NSW	*Wagga Wagga*	Outback	35.2	41.6	12.0	10.1	22.9	16.1
VIC	*Walpeup*	Outback	36.3	44.8	11.0	12.7	26.6	16.7
SA	*Minnipa*	Outback	37.2	44.9	12.0	12.6	24.9	16.9
NSW	*Moree Livingston*	Outback	38.1	46.4	12.0	10.0	28.0	16.6
WA	*Newdegate*	Outback	38.8	39.6	13.0	14.2	29.7	20.2
VIC	*Horsham*	Outback	39.3	37.8	13.0	10.9	27.8	18.6
SA	*Lameroo*	Outback	41.1	37.7	15.0	13.6	25.3	17.3
VIC	*Beulah*	Outback	42.4	38.7	12.0	12.8	31.1	17.8
WA	*Wongan Hills*	Outback	43.9	34.9	11.0	14.1	31.0	23.2
NSW	*Wagga Wagga*	Rainbow	35.5	41.3	13.0	9.7	23.7	16.1
NSW	*Moree Livingston*	Rainbow	37.0	47.0	12.0	10.3	25.8	16.3
SA	*Minnipa*	Rainbow	37.4	44.4	9.0	11.8	24.2	15.3
WA	*Newdegate*	Rainbow	39.2	40.2	12.0	16.7	30.9	20.6
SA	*Lameroo*	Rainbow	41.4	36.3	12.0	13.7	28.0	17.4
WA	*Wongan Hills*	Rainbow	44.3	36.8	10.0	13.0	28.7	22.1
NSW	*Wagga Wagga*	Rivette	37.7	45.2	13.0	8.8	20.3	13.6
NSW	*Moree Livingston*	Rivette	38.4	50.1	10.0	9.1	25.9	13.8
VIC	*Walpeup*	Rivette	38.6	47.5	10.0	11.3	24.1	14.8
SA	*Minnipa*	Rivette	38.9	47.1	13.0	10.3	25.0	14.0
VIC	*Horsham*	Rivette	40.7	42.6	12.0	10.0	24.9	15.2
WA	*Newdegate*	Rivette	41.5	42.8	10.0	11.0	25.0	14.3
SA	*Lameroo*	Rivette	45.0	39.0	11.0	11.8	29.1	15.1
VIC	*Beulah*	Rivette	45.1	41.8	8.0	11.6	25.4	14.8
WA	*Wongan Hills*	Rivette	48.4	39.7	7.0	13.4	26.4	18.7
	Mean		**40.3**	**41.8**	**10.8**	**11.9**	**26.6**	**16.9**
	Minimum		**35.2**	**34.9**	**6.0**	**8.8**	**20.3**	**13.6**
	Maximum		**48.4**	**50.1**	**15.0**	**16.7**	**31.1**	**23.2**

Source NSW Agriculture Oil Research Laboratory
*** Oil and glucosinolate values reported at 6% moisture in whole seed*
**** Protein values reported at 10 % moisture in oil-free meal*

5.4 Canola Meal Usage

Canola production has increased dramatically from around 100,000 tonnes in the early 1990s to a peak of 2.4 million tonnes in 2000. Since then, production has stabilised around 1.6-1.7 million tonnes. The major driver of crushing demand is the demand for oil, with meal largely a by-product. Around 400-450,000 tonnes of canola seed is required for domestic oil consumption and thus, the majority of Australian canola seed is exported. In order to increase local processing of seed, there is a need to improve the value of canola meal and identify export opportunities for the oil. A likely increase in the production of biodiesel from canola oil will significantly increase the amount of available canola meal.

The amount of meal produced in Australia per annum is variable and it is difficult to obtain accurate estimates. There has been a progressive increase in canola meal usage over the last five years, which is reflected in Table 6.

Table 6. Australian annual canola seed and meal production (tonnes).

Year	Seed	Canola meal*
2003/04	1,622,000	274,000
2002/03	790,000	224,000
2001/02	1,608,000	239,000
2000/01	1,681,000	172,000
1999/00	2,402,000	222,000

* 75% solvent extracted; 20% expeller; 5% cold pressed

The oilseed meal market in Australia consists of:

- Domestically produced canola, cottonseed, soybean and sunflower meal
- Imported soy and palm kernel meal

Protein meal usage increased to over 900,000 tonnes in 2002/03, largely due to the highest level of soybean meal imports in many years and significant imports of palm kernel meal (Table 7). In total, soybean meal imports increased by 45% on the previous year to around 370,000 tonnes.

Table 7. Protein meal (all crops) usage in Australia

000 tonnes	2002/03	2001/02	2000/01	1999/00	1998/99
Canola	224	239	172	222	183
Soy*	375	270	195	75	100
Sun	13	4-	42	70	110
Cotton meal	175	190	285	254	220
Palm kernel meal*	121	92	20	17	16
Sub-Total	*908*	*791*	*714*	*638*	*629*
Cotton seed whole	140	200	260	240	350
Canola seed whole(e)	25	N/a	N/a	N/a	N/a
Sub-Total	*165*	*200*	*260*	*240*	*350*
Total	**1073**	**991**	**974**	**878**	**979**

** includes imports*

In general, there is greater demand for meal than domestic production with this currently being fulfilled by imported soybean and palm kernel meal. There are some small exports of canola meal (less than 2000 tonnes) mainly to the Pacific Islands and Vietnam. At times there has been difficulty in clearing meal, particularly solvent extracted meal, due to the relative value placed on this by the user industries. Expeller meal forms only a small part of the market e.g. 20% and there has been little change in demand over recent years and generally no carry over.

Increased canola production and strong growth in the intensive livestock sector has contributed to the increased demand for canola meal in Australia. The feed grains industry now utilises around 10 million tonnes of feedstuffs and is continuing to grow. Oilseed and oilseed meals represent around 10% of this total feed grain usage. Over the past five years canola has represented 30% of total meal usage as has as cottonseed meal, although this is declining as the volumes crushed fall. Over a five year period, soy meal has only accounted for 10% of usage, but has been increasing as demand grows and in 2002/03 accounted for over 40%.

While this report is focused on improving the value of meal in the domestic market, improvements to the quality and quantity of protein will also assist the export sector. Development of education activities may also assist the export sector in expanding use of canola meal and therefore demand for seed in countries that have not traditionally used canola or use high glucosinolate rapeseed e.g. Pakistan and Bangladesh.

Usage by livestock sector

Oilseed meals are predominantly used by the monogastric sector. As indicated in Table 8, the poultry sector is the dominant user of canola, although the pig and dairy sectors are also important. Canola meal has more recently become popular with the dairy industry as this industry has moved more towards use of feed rations in conjunction with pasture. In terms of growth potential, the dairy industry probably offers one of the best opportunities. Currently, the poultry and pig sectors account for more than 60% of oilseed meal use.

The stockfeed industry relies on consistent supply and quality and thus, is vulnerable to shortfalls or variations in quality. With increasing animal production and possible banning of meat and bone meal, vegetable protein meal and grain demand are likely to significantly increase.

Table 8. Consumption by species

Livestock Sector	Feed tonnes (SFMA est)	Veg. protein usage (SFMA est)	Veg. protein usage (AOF est)	Canola meal (AOF est)	Canola meal % of protein meal (AOF est)
Pigs	1,698,000	212,000	246,722	44,410	18
Poultry	2,730,000	309,600	361,040	158,858	44
Dairy	2,517,000	125,000	145,576	23,292	16
Feedlots	2,033,000	101,000	116,432	1,746	2
Aquaculture & other	425,000	31,800	38,230	2,294	6
Total	9,403,000	779,400	908,000	230,600	

Product usage is closely related to price with substitution between products in feed meal formulas. Despite this, the requirements of different species can increase demand for one product over another. For example, fibre is of limited use in poultry and young pigs, but is useful for ruminants. Protein quality and energy levels play an important role in determining usefulness of individual meal types.

Nutrient requirements are well understood by the industry and have been calculated for different species and for different stages of growth. Amino acids and energy are the key requirements and this data is available in various references. Accurate supply of those two components is essential to keep costs down.

It is likely that there is a potential to increase production of canola meal in Australia at the expense of imported soybean meal. The requirement for GMO free products may hasten the use of canola meal in many instances.

Poultry utilises primarily solvent extracted meal (around 90%). Usage increased significantly through the 1990's, but more recently there has been a resistance to further increases. This is due to perceptions often related to rapeseed as well as problems with variable quality and cost.

Maximum amounts stated in various research reports are used as potential inclusion levels, but seldom are those upper limits utilised. Inclusion depends on the type of meal including starter, finisher, grower and withdrawal rations. Broilers account for majority of tonnage in the poultry industry, with inclusion levels varying from 0-30%. The industry uses a range of 0-12% but, more commonly, around 7-8%. Some research studies had shown that canola can be used up to 40% in broilers. Brown egg layers are susceptible to anti-nutritional components of the meal and diets are capped at 7%. Individual inclusion levels in formulas vary from 2-5%.

Usage in the **pig** sector is concentrated in the hands of a few large companies. Generally solvent extracted meal is used, although significant quantities expeller meal are also used. Overall usage is increasing in all pig diets across the industry as new users incorporate canola meal into their formulations. The potential for increased usage is high given the large gap between major users and new users. There is no cap for canola meal usage in pigs, but rations typically range from 0 – 20%, with average usage around 12%. Usage varies by diet e.g. weaners 10%, growers 20% and lactating sows 15%.

Canola meal is used in processed **dairy** rations by stockfeed manufacturers and by dairy farmers mixing their own feed. There has been an overall reduction in use recently due to the general downturn in profitability of the dairy industry due to low milk prices and poor seasonal conditions. This has resulted in cost cutting and reduced expenditure on supplementary feed. This is considered a temporary situation. Prior to this there had been an increase in overall usage, particularly in northern Victoria. There are restrictions on the use of GM product in dairy rations i.e. need to supply 95% GM free, and thus, soy meal is not used by this sector.

Ruminants have no cap for canola inclusion, but generally inclusion is based on price and urea can be used to replace significant proportions of the protein resulting in a considerable reduction in price. The ruminant industry prefers canola due to the quality of the by-pass proteins. Dairy cattle diets contain 30-40% protein meal with about 5-20% being canola. Typically in a cow diet of 20-25 kg dry matter/cow/day, 2-3 kg or 10-13% canola meal was suggested to be optimal. A special calf diet of 20% was used for calves. Inclusion levels by stockfeed companies are relatively low i.e. can be less 5%

For **beef cattle**, usage is low at around 3% in specialty diets where pasture is the major component. Canola is used in limited in cases to achieve rapid production or for cases to improve fat colour.

Usage is minimal in the **sheep** sector. It is confined only to some prime lamb production or specialty animals where fat colour and consistency is important. Little change in usage is expected.

Currently only 5% of **aquaculture** feed components is canola meal. The industry is expanding, but it is limited by coastal development. The catfish industry in particular may be increasing, but overall there is little change. It is likely that caged aquaculture will increase. There is good potential for increased usage of canola meal for both domestic aquaculture production and in overseas markets such as Taiwan. Some studies on fish have shown that it is possible to use up to 60% canola meal in the diet. Aquaculture nutritionists in Australia reported much higher usage rates of canola meal overseas.

Currently, there is little, if any, canola meal used for pet food or horse feed. Some small amounts are used for game birds (max 3%), rabbits, etc. Potential usage is significant as the major limiting factor is lack of knowledge. The industry is anxious to learn more to provide them with other alternatives. In pet food, price was not an important factor and formulas are not based on productivity. Pet formulas are prepared based on feeding experiments in catteries and with domestic dogs. Generally faecal output is a major consideration together with antioxidants and components for shiny coats, etc.

5.5 Competitive Factors for Canola Meal

All livestock feeds are calculated using least cost ration formulations and thus, everything is substitutable at a price. Therefore, usage depends on alternative product costs and availability. Ray King (2001) noted that there are over 100 alternative ingredients available to pork producers alone. Freight costs and sites also play a strong role in determining feed components.

Canola is generally considered a better meal at the same price with a good amino acid profile, mid protein, mid fibre, and ME and DE better than most others. Canola substitutions vary depending on location and the cost of freight. However, common ingredients include soy, sunflower, lupins, peas, cottonseed, chickpeas, mung beans, faba beans and safflower. In WA and southern NSW, the major substitute is lupins although it is less common in the north where sorghum is more prevalent. Meat meal, blood meal and fish meal are used for monogastrics, but are not permitted for use in ruminants. Meat meal and related products may become limiting in the future due to health concerns which would be a direct advantage for canola.

Sector	Common Substitutions for Canola Meal
Poultry	Soy, cotton and sunflower are alternative protein meals. Lupins are popular, particularly in WA, Southern NSW and Victoria where they are price competitive. Other pulses are also substitutes and more competitive than lupins in the north. Fish-meal, meat-meal, blood-meal and bonemeal are used. Canola meal has a good amino acid profile for poultry and is comparable with soy when costs and live weight gains are taken into consideration.
Pigs	Soybean meal is the benchmark. Lupins, peas, cottonseed and sunflower meal are used.
Dairy	Cottonseed, linseed and soybean meals are common. Alfalfa, lupins, lentils, beans and corn are used as supplements to pasture.
Beef Cattle	Lupins, urea, cotton seed and cottonseed meal, soy and peas are common. Copra has increased in recent years due to unavailability of canola. Dry distiller's grain is increasing.
Aquaculture	Soy meal is a major component, with additional additives of lupins and wheat gluten.
Pet food	Canned food is almost exclusively animal product whereas dried food contains soybean, maize, gluten and various plant proteins. Sunflower oil is added to provide essential linoleic acid to the diet. Meat, bone, fish and poultry meal are also used.

6.0 Limitations

The following analysis has been drawn from a qualitative industry survey, literature review and other desk top research. It is not meant to be a definitive review, but rather capture the perceptions that suppliers and users hold and identify the issues impacting on usage of canola meal, whether real or perceived.

6.1 Quality Benchmarking and Testing

- Standards

  The AOF trading standards are shown in Table 1. These standards were initially created based on production quality rather than end-user requirements. Some of the standards are, therefore, lacking in specificity (e.g. crude protein and crude fibre). However, bulk handlers and crushers relate to these standards for their benchmark. The standards may be negotiated on sale of meal depending on quality out-turn and currently, due to high protein levels in canola crops, meal is often being traded above the 34% protein standard. One crusher indicated that the aim was for “zero salmonella”, “zero pesticides”, a minimum protein of 37% and food safe. There are currently no standards for many of the minor components and anti-nutritional factors (e.g. sinapine, NDF, ADF) in canola meal.

- Testing

  There is little testing for specific customer needs by bulk handlers or crushers. End-users do test for some of these factors such as amino acids, NDF, colour, carbohydrates. Canola meal is purchased from processors, at a nominated protein/moisture/fat level, generally based on AOF Trading Standards. Millers carry out various degrees of testing ranging from very minor testing to detailed NIR analysis and analysis of available amino acids. The most detailed testing is done by research organisations where a large part of the quality data on minor components has been generated.

- Predictive values

  The quality of amino acids is commonly predicted from text book values or research studies, often based on overseas research, due to the cost and time constraints of testing each batch. It is well known that the quality varies considerably between extraction plants and because of environmental differences. This has particular consequences for canola which is valued at the lowest level of the range for those quality parameters. As a result, excess amino acids are being used to ensure adequacy. Despite the adequate supply of minerals and apparent good level of vitamins, there is no value given to these components, with all of the required vitamins added synthetically.

- Benchmarks

  Benchmarks vary between industries. Often the benchmark is against alternative feedstuffs, e.g., comparison of productivity against lupins or soy meal is a common measure used. Quality benchmarks to factor in canola are generally off imported soybeans, due to the large number of research studies in the past and industry acceptance based on experience.

  Benchmarking may include feeding trials, productivity and other performance measures. Some organisations have several nutritionists and do their own research studies on production. Measurement of quality seemed to be more thorough in the pig industry. In that sector where feeding and performance are easily monitored and the level of sophistication is high, productivity is the key benchmark. Theoretical values for anti-nutritional and minor components are used by less well established organisations.

  The more sophisticated producers carry out their own analysis using NIR spectroscopy and amino acid analysis to formulate meals on actual batch quality.

  Benchmarks for ruminants are mostly based on productivity. Generally the dairy industry bases its formulations on milk production.

- Information

  There is generally little information on out-turn quality from crushing plants other than the basic values of crude protein, moisture, oil content, retention on 2mm screen and hexane residues. Some quality aspects can be controlled, but others cannot and, therefore, monitoring has limited value. In most cases, millers do the majority of the testing including amino acid analysis, NDF, ADF and other detailed tests. There is an abundance of information available from research studies and trials both in Australia and overseas, however, the availability of this information can be unknown or difficult to obtain.

6.2 Quality Issues and Limitations

This section discusses the quality issues and limitations raised during the survey. The table below identifies the key issues as identified by the survey participants. This does not imply that the issues not marked do not impact on that sector, but were not nominated in the discussions.

	Poultry	Pigs	Cattle	Sheep	Aquaculture	Pet Food	Crushers
Consistency	×	×	×	×			×
Bio-security	×						×
Sinapine	×	×	×			×	
Fibre	×	×				×	
Amino acids	×	×		×			
Fat/oil content	×		×		×		
Erucic acid	×				×		
Glucosinolates	×	×	×	×	×		
Net energy		×					
By-pass protein			×				
Palatability	×		×				
GM status			×				
Infertility			×	×			
Colour				×		×	×
Minerals/Vitamins						×	
Protein quality							×
Moisture	×						×

- Consistency

Consistency, or lack of, is a major factor that limits the use of canola, in particular in relation to protein content. This makes it difficult to predict meal quality as each processor produces a different product. Available amino acid content is estimated from crude protein content as it is time consuming and expensive to analyse. Improved consistency could, therefore, avoid over or under estimating rations. While environmental variation is the major factor, consistency also varies between processors and the type of process used. Expeller meal tends to have less damage through application of heat.

For the ruminants sector, by-pass protein values are based on a theoretical value which seems to be effective and favours canola over lupins.

- Bio-security

This is a key issue for the poultry industry where contamination with salmonella could cause major problems and appears to be one of most limiting factors in canola meal usage. Canola meal is apparently more susceptible to contamination than other protein meals. Moisture content may be significant in handling this problem with reduced moisture giving less contamination. However, there is also a relationship to processing damage of amino acids through heat treatment at the processing plant and again during pelletising which is considered necessary to ensure removal of salmonella.

- Sinapine

Sinapine is a major limitation in that it reduces feed palatability due to bitterness of the meal and causes taint in eggs from brown egg layers. Studies in Queensland have shown that >10% canola meal will produce fishy flavour in brown egg layers and is another restriction to canola use. This has been a factor in reducing usage in recent years.

Generally there was no concern about sinapine in the pig sector, although, as for the other industries some thought there was a preference for other products due to feed palatability. Palatability was seen as a problem in WA in young pigs.

Sinapine was also reported by some in the cattle industry to reduce palatability; however, this was contradictory with some saying stock selected against canola presumably because of taste, while others saying some cows "knock you over to get at it". It appears that cattle become used to canola meal, particularly if they are weaned onto it.

Palatability is essential in pet food which may make sinapine an obstacle.

- Fibre

Fibre is an important issue for monogastrics, but is able to be minimised by use of enzyme addition. There would be an advantage if fibre could be reduced through breeding. Fibre ratios (e.g. the NDF/ADF ratio) are important rather than crude fibre. There was a need to understand how fibre works. In pigs, fibre is good in dry sows as it fills them up, however, baby pigs have a problem with fibre as it is digested in the hindgut which is undeveloped in babies.

The soluble and insoluble fibre is of particular importance in pet food due to the need to maintain faeces consistency.

- Amino acids

Amino acids are important and heat damage in processing is of concern.

In the poultry sector, protein digestibility has been the subject of several research projects and considerable data is available. Heat treatment is known to damage amino acids. In addition to high temperatures of the toaster/desolventizer at the crushing plant, meals are subject to heating again at 90-95^{o}C during pelleting resulting in a reduced percentage of amino acids available due to processing. This variable damage is a problem as there is difficulty in determining actual availability in subsequent batches of canola meal. Table 9 illustrates the variation in lysine availability from different processes.

For pigs, high levels of crude protein, digestible lysine and methionine are important. Numerous studies on available lysine and rapid methods to measure amino acids have been discussed in previous literature.

Table 9. Lysine content of canola meal from solvent extracted and mechanically pressed

Lysine (g/kg DM	Seed	Cold-pressed	Expeller	Solvent extract
Total lysine	11.68	17.41	17.25	18.70
Reactive lysine	8.83	13.00	10.88	11.38

Source: van Barneveld – 1998.

- Fat/oil content

The oil content of meal varies depending on the source of the meal i.e. solvent extracted meal may contain less than 1% oil whereas cold pressed or expeller meal may be up to 12%. Some linoleic acid in the oil is essential for poultry and limitations may result in loss in vitality, growth and production.

Too high an intake of canola oil in dairy diets was said to be undesirable as it may upset rumen function and digestion. However, canola oil in meal, that can escape hydrogenation in the rumen, may increase polyunsaturated fat (pufa) levels in milk and thereby improve the nutritive value.

The oil content of the meal is significant for fish and in aquaculture diets and oil is added to the meal for the supply of essential fatty acids. Canola oil is preferred if oil is added. The price is very cost effective and the fatty acid profile is the best of the oilseed meals.

- Erucic acid / Glucosinolates

Erucic acid in the oil and glucosinolates were generally not considered important. However, in the poultry sector there were perceptions about canola meal being a problem based on memories of rapeseed meal. It was repeated by participants several times that if there is a problem with poultry, the first thing that is removed or reduced from the meal was canola, generally based on perceptions or individual preferences.

This is not an issue in pigs. Victorian studies have used up to 30% in pig rations with no problems using meal with very low glucosinolate levels. Some studies have been done with pigs in W,A however, showed reduced growth rates with higher inclusion levels of meal containing approximately 10 µmoles/g of glucosinolate. This reduced performance was attributed to the glucosinolates. This is significant because canola glucosinolate content can vary from year to year from around 4 up to 20 µmol/g. Generally there were no other direct results which indicate problems with anti-nutritional components.

Reduced fertility in dairy cattle has been reported. This is a potentially major problem for canola where at 3 kg/cow/day, fed during drought periods, fertility in dairy cattle dropped. These findings were said to be in little doubt and were attributed to the level of glucosinolates and goitrogenic products in the meal.

Based on earlier research, reduced growth rates for aquaculture were reported with high inclusion levels and this was attributed to the presence of erucic acid in the oil and glucosinolates in the meal. The scientist was not aware that erucic acid was virtually zero in canola oil and glucosinolates were very low compared to early types. This perception needs to be evaluated.

- Net energy

  This is seen as a critical factor in meal utilisation and researchers felt that canola meal may be higher in energy than previous studies have considered. Feeding experiments have shown it to give better results than would be predicted from theoretical values and also better than lupins.

- By-pass/Indigestible protein

  The percentage of by-pass protein and digestible protein is important in ruminants. Canola is said to be a good management tool for managing weight, fertility and production. A good ruminant meal requires a balance of by-pass protein and digestible protein, to support rumen microflora. Canola is apparently a poor source of rumen degradable protein. Cottonseed was said to contain 40-44% indigestible protein whereas canola may be as high as 50%. Extra heat during processing to increase by-pass proteins is not necessarily beneficial to cattle feed. From the comments of some consultants, it would appear that there is some confusion about the benefits of by-pass protein by various segments of the industry.

  The science of rumen digestibility creates complexities in determining diet formulations. Canola is considered a good protein source because of the by-pass protein required to get protein passed the rumen. However, there is also a need to have ruminant digestible protein to support microbial activity. High ruminant degradable protein is required by microbes to assist and to provide time to digest cellulose in the rumen. Formulations are designed to alter the time and digestion in the rumen to optimise digestibility and maximise productivity. The measurement of effective neutral detergent fibre (NDF) also seemed to be more meaningful as crude fibre “means nothing”.

- Colour

  Colour has been considered to be a product of endogenous tannins in the seed and to the colour of the seed coat. Colour, however, is influenced more by high cooking temperatures. The addition of gums back into the meal after solvent extraction also contributes to dark meal. These gums contain around 30% oil and 70% acetone insolubles including waxes, pigments, phosphatides and sterols. It is a convenient way of removing waste gums for the industry, but the added value needs to be considered.

The dark meal colour and burnt odours indicate cooking damage and there was a need to better understood and control the cooking process. Colour is an important consideration for pet food and may limit the inclusion of canola meal. The benefits are basically that coloured particles are more visible in light coloured pet food which gives the perception of nutritional benefits. This is more of an appeal to the owner of the pet. Unusually, the darker colour was said to be good in dairy.

- Minerals and Vitamins

  Endogenous vitamins are ignored in canola meal although Canadian literature indicates there are significant amounts. Vitamin content is calculated as nil and the full requirement added as synthetics. Calcium and phosphorus, amino acids and vitamins are important as is magnesium for cats. Pet food is based on maintenance, not growth. It aims to supply antioxidants, produce shiny coats and focus on health.

Some of these quality issues are impacted by processing. The key issues for crushers to manage include:

- Protein quality - The effect of heat damage on meal during desolventizing/toasting is not well understood. Undoubtedly the desolventiser/toaster process contributes significantly to meal damage. There were several references to Prof. Classen's work on heat treatment indicating that the use of direct steam on meal was excessive. The D/T process is known to effect quality and the temperature is therefore generally maintained at 105-110^{o}C. However, during the expeller process operators may also use higher than optimal temperatures to improve oil extraction. Some processes were running at considerably higher temperatures than others and would be expected to produce significantly different meal quality. The optimum time and temperature needs to be determined to obtain maximum protein protection. The effect on protein availability, whilst generally acceptable for ruminants, is not ideal for monogastrics or aquaculture. Cold press extraction is considered to have an advantage over other methods as it is said to be done at < 58^{o}C.

- Moisture - Solvent extracted meal is usually adjusted from around 2% after solvent extraction, up to 10-12% by steam injection to fit within the trading standards. Moisture contents on cold press meal is only 5.5 – 8%. The moisture and fat concentration in solvent or cold press meals will effect the levels of protein and other components in the meal.

- Biosecurity - The cooling process is considered the source of the biosecurity problem due to possible contamination at that stage. High moisture may also contribute.

- Colour - At each of the solvent extraction plants it was noted that gums from the degumming process are added back into the meal after solvent extraction. Although this is considered to increase the energy value of the meal it also has a negative effect on colour.

- Consistency – It was said that meal from the crushing plants was generally consistent in crude protein content by the time it was solvent extracted due to mixing and blending. This could also be controlled by controlling the areas from which grain was sourced. However, end-users did not always agree that it was consistent.

6.3 Quality Perceptions and Limitations

There is a range of issues limiting canola meal usage which are perception or attitude based or arise through poor communication. These include:

- *Negative reputation* - There are many perceptions about canola meal which may be inaccurate. Significant amounts of canola are used when everything is going well, but when things go wrong canola is the first to get attention. As a result, canola meal is undervalued and end-users may be missing out on opportunities.
- *Communication* - Lack of communication of facts to the industry is a limiting factor. This is certainly the case in relation to anti-nutritional components in the seed such as glucosinolates and erucic acid which have now been reduced to minimal levels in current cultivars. For example, erucic acid in the oil residue in meal is unlikely to cause a problem at <0.1% of the fatty acids. However, this is still perceived to be a problem.
- *Recognition of the value of canola meal* - Old perceptions of rapeseed are disappearing and the value of canola meal is being recognised by many. However, the achievable increases in productivity and true quality of canola meal are not widely accepted. Education and a better understanding of canola meal is required to assist in this transformation. For many, canola meal is still being valued at around 34% protein whereas it more typically falls in the 36-38% range. Variability is a key issue and in areas where high oils are achieved, protein will be lower. This is less of an issue on the east coast due to the volume of canola produced and the ability to average out protein. In recent seasons, this has been an issue in WA as climate and the contraction of oilseed production to the better areas has seen oil content increase and protein levels fall.
- *Management attitudes* - Management attitudes create uncertainty about the benefits of canola. This needs to be overcome by research, but also by education and communication. Millers have restrictions on usage which is sometimes based on old data. It was said that usage would increase with adjustments to limits if those current limits were based on incorrect information. Once rations are established for an industry it appears that it is difficult to get change. The recent drought saw an increase in copra as an additive and once imbedded in the formulation it is apparently hard to change.

- *Nutritionist preferences* – Nutritionists have their own preferences and many know soybean from the extensive research that has been carried out, and tend to stay with old ideas. Management are quick to blame poor performance on canola. Nutritionist attitudes have been partly responsible for maintaining canola usage at minimum levels.

7. Opportunities

7.1 Trends/potential

All participants agreed that there is considerable potential for increasing canola meal usage. With the removal of some of the limitations outlined above, potential usage was considered to be significantly higher than current use. In past years, canola meal has not been difficult to sell and there has been little marketing involved. Increasing proportions of canola meal in feed supplements together with an increase in the size of the industry will result in higher demand. This would be assisted by the possible future banning of meat-meal, fish-meal and animal products from animal feeds. Potential new uses for canola oil such as biodiesel may see increased amounts of meal available.

Potential usage various by sector. Trends in usage and potential as seen by survey participants include:

- Poultry - The poultry broiler industry in NSW could double or triple its usage from 7 to 20%. It was said that the industry could use up to 20% starter broilers and 30% in finishers. In WA it was suggested that usage could be doubled in layers and were willing to increase inclusion levels to 5% if eggs and meat are shown not to be affected, and this combined with a 3-4% increase in production will increase meal utilisation.

- Pigs – Possible that usage could increase by five times if all growers adopted the high utilisation rates of some of the main producers.

- Dairy - Usage in the dairy industry is very variable with part of it being very intensive and the rest being pasture based. There are also a lot of variables in cattle stages including calves and lactating cows. However, the feeling was that this industry could also double canola usage. Canola is said to increase production and when returns for milk are high, the industry will use more.

- Aquaculture - Although the industry is small in Australia it was felt that there is a huge potential market for overseas use such as Taiwan. Australian producers also consider canola meal has potential for increase from the low levels of inclusion used currently.

- Pet Food - There is good potential for growth as the pet food industry is basically unaware of canola meal. One of the limitations is colour as dry dog food needs to show coloured admixture and soy meal has better visual properties.

Table 10. Potential consumption by species

Livestock Sector	Feed tonnes (SFMA est)	Veg. protein usage (AOF est)	Potential veg. protein usage (AOF est)	Potential canola meal (AOF est)	Canola meal % of protein meal (AOF est)
Pigs	1,698,000	246722	257418	77,225	30%
Poultry	2730000	361040	381360	209,748	55%
Dairy	2517000	145576	152544	45,763	30%
Feedlots	2033000	116432	114408	1,716	2%
Aquaculture & other	425000	38230	47670	4,767	10%
Total	9403000	908000	953400	339,220	

Growth will be a combination of sector growth in feed consumption and increased share of protein meal consumption by dairy

For ease, growth in protein meal consumption has been around 10% per annum over last four years so conservatively estimate 5%

Then assume an increase in canola meal as percentage of total meal used from 30% to 36%

7.2 Potential Initiatives to Address Issues

The following suggestions are those put forward by survey participants. These have been considered in developing the priorities and recommendations.

- Education and communication for the user industries

  Better education of end-users would be the first step in achieving the potential growth in canola meal usage as much of the information about canola currently being used is old data or inherited from previous nutritionists. The issues that need to be addressed in an education program are the differences between rapeseed and canola; the benefits of canola meal and potential inclusion levels. Preconceived ideas appear to be limiting opportunities for canola meal. Activities that would assist could include:

  - workshops with major players from the industry
  - information sheets with data on the final product that illustrates the very low levels of glucosinolates and erucic acid
  - an education program about the quality of canola meal to identify the amount and type of available amino acids, vitamins, and minerals. Currently this is based on predicted losses rather than real values to ensure adequate availability as it is too expensive to do amino acid analysis on individual batches
  - determine and communicate conversion rates of ADF to feed value and to apply this to least cost formulas including tables to show how to prepare conversions for use of proteins, fibre and vitamins for feed formulae
  - information for potential new users e.g. the pet food industry

- Education and communication for processors includes a better understanding of:
  - the effects of environmental conditions e.g. drought on quality of canola seed
  - fibre content (ADF/NDF/crude)
  - amino acids and other quality characteristics
  - the effects of processing conditions to get better uniformity
  - the effects of temperature/time/moisture content in processing on protein quality i.e. an education program on values such as presented by Prof. Classen is required

- Improvements in inherent qualities
  - Reduced Fibre - Fibre levels in Australian canola have been shown to range from 9-17% (Table 5). This is a restriction and reduction to lower levels would assist in increasing consumption. Fibre is an important characteristic in designing formulations. One research group suggested that a full life cycle study on poultry egg and meat production, including the use of enzymes to reduce fibre, is required.
  - Protein content – breeding of cultivars with increased protein and an improved profile.
  - Protein quality – It is perceived that processing is the major factor impacting on quality. Changes to the process could improve quality, particularly in relation to digestible and by-pass proteins. Toasting and pelletising is done at around 90-110^{o}C or more. Prof Classen (AOF GM Feb 04) showed graphs on temperature/time/moisture content that indicate quality can be improved. There is a need to understand degradation of meal during the oil extraction process in the desolventiser/toaster. Although there are many ideas about the benefits or detriment of this process, the degree of cooking and effects are unknown. The question of "how much cooking is necessary to get the optimum by-pass and digestible protein" needs to be answered. It is possible that some of the information is already available, such as that from Prof. Classen, and distribution and explanation may be a starting point.
  - Colour - A study on the value of adding products from the degumming process back into the meal would be useful to determine if it benefits the meal quality. It seems that the gums darken the meal, which is a negative aspect. The disposal of gums could be a major problem for processors, but this needs to be offset by the potentially reduced nutritional value when added back into the toasted meal.
  - Sinapine – There is a need to reduce sinapine in order for canola meal to reach its full potential. A study of the amount of choline, a component of sinapine, in various feeds would be useful to better understand the effects of sinapine on egg taint. Choline, which is high in canola meal, is present in free and fixed forms and the function is not well understood. A project to study and selection of different strains of layers to select away from fishy taint may be an alternative method of coping with sinapine.

- Amino acids – Deficiencies are generally accepted and not generally perceived to be a problem as synthetics are available. It is recognised that steam degrades lysine and synthetic product is added back to the perceived required levels. Similarly vitamins and minerals are cheap and are added in total and encapsulated and coated on pellets. For poultry there needs to be better understanding of amino acids such as threonine which is not price competitive to add although it is not usually limiting. There was a desire to increase the sulphur containing amino acids. Milk production is increased with cystine and methionine amino acids. Increased histidine/histamine were considered a benefit for cattle.
- Infertility – One consultant considered it as "beyond doubt" that canola meal is the cause. If there is any possibility of this, the issue needs to be resolved. A study of the effects of feeding canola meal on the fertility of cattle was suggested.
- Glucosinolates – These are considered anti-nutritional factors for fish. A study on anti-nutritional components, particularly glucosinolate concentration on growth rates is required. Some digestibility studies on tannins and fibres in fish could be done despite the difficulties in measuring faecal output.
- By-Pass Protein - Many people understand the concept of reduced digestibility of protein and the increase in by-pass protein with heat treatment of canola meal. This is apparently important for ruminants, but not for monogastrics. However, there appears to be some major misconceptions about the benefits of heat treatment and the need for high levels of protein. Although some participants pointed out the value of very high temperatures, up to 130^{o}C, others voiced concern at the destruction of amino acids at high temperatures. A ruminant nutritionist pointed out the need for digestible protein in the rumen at optimum ratios to support microflora digestion of cellulose. He pointed out that high levels of by-pass protein left the cellulose undigested and the feed under-utilised. It would appear that this information is freely available in the literature, but requires dissemination and education of processes, feed manufacturers and nutritionists.
- Net Energy - There is a question regarding the net energy in canola meal for pigs, which may be higher than predicted. This was suggested as feeding trials have shown better performance than theoretical values would predict. Pigs eat the same amount, but grow faster. A study on net energy would be valuable similar to what has been done on lupins. The model for such an experiment is already available at Werribee.

- Other issues
  - A study on reducing the potential for contamination of meal after the cooling process such as reducing the moisture content.
  - Assess the potential for segregation i.e. it was considered if segregation of different types of meals, such as monogastrics and ruminants might be an opportunity to make more specialised and better targeted products. Millers, however, would not like 2-3 types of meal due to storage limitations. This was clearly a restriction for many of the people interviewed. There is no selection, segregation or design of meal for end users. All the industry sectors have specific needs, however, the AOF Trading standards only relate to basic crude protein, moisture and crude fibre. There may be a place for grading seed as in Canada although this may be based on two products, high oil/low protein seed and low oil/high protein seed. At the extremes, canola seed can vary from 36-48% oil with an inverse relationship of 36 to 45% protein in the meal.

There was interest in conducting feeding trials from all of the industries including crushers, millers, poultry, pigs, fish, beef and dairy cattle and the pet food industry.

Crushers showed an interest in taking part in evaluation of cooking processes, temperatures and times, to determine the optimum conditions for producing the best meal. It would appear that meal could be acquired from solvent, expeller and cold press operators.

Researchers are keen to work with this type of meal and several participants with feed trial facilities are both willing and able to be part of these types of experiments. Feed millers as well as nutritionists in both eastern and western states considered such experiments would be worthwhile.

7.3 Benefits to the Industry

There would be a number of benefits for the industry – from growers to end users – from improving the value and utilisation of canola meal. Benefits would include:

- Ability to calculate precise rations based on real values
- Canola would be more readily and more consistently used
- New markets established e.g. pet food, where canola is unknown
- Increased demand for meal in Australia and reduced dependence on imported soy meal
- Economic benefits for feed manufacturers from substituting high cost soy meal
- Improved performance and productivity of livestock.

7.4 Chance of success

There was unanimous support for research studies and a high level of confidence in successful improvement in canola meal quality and utilisation by the industry. Feed manufacturers, researchers, and participants from the poultry, pork, cattle, aquaculture and pet food industries felt there is no doubt that canola meal usage can be increased through research and education. Particularly, an improvement in the current understanding of anti-nutritional factors, improved amino acid availability and better analytical techniques such as NIR spectroscopy will ensure an increase in consumer demand in Australia and enhance export opportunities.

Several of the recommendations listed here have previously been studied in great detail as can be seen by the extensive reference list. There is an abundance of information available regarding canola quality, including glucosinolate levels, erucic acid and crude protein. Several studies have been carried out on pig and poultry nutrition to indicate optimum levels of canola meal inclusion.

Despite this, there are many perceptions about the limitations of canola meal. Comments from many areas of the industry showed that inclusion levels were often based on preconceived ideas or personal preferences. With this in mind, there is little chance of success in achieving deliverance unless there is a major effort to communicate and educate the end-users of the product. This may be in the form of workshops, publications, website information or handouts/flyers with particular industries and quality parameter targeted.

For example, a reduction in glucosinolates was considered to be necessary to achieve higher utilisation. However, despite considerable reduction, some end-users are not aware that glucosinolate content is very low compared to earlier cultivars. This may be the case for fibre where considerable effort may be allocated to fibre reduction, but without the communication of these new benefits, no change in utilisation will occur.

Many of the priorities given here are achievable and through the integrated participation of breeders, research scientists, crushers, feed manufacturers and nutritionists, can be transferred to the end product. The crushing industry is aware of the effect of high temperature on amino acid availability and with co-operation of research projects may be able to refine their methodology to produce a more consistent and nutritional product. Some of the priorities may be considered uneconomical and better achieved by other means such as the continued use of synthetic amino acids and vitamins.

8. Summary

The production of canola meal is largely determined by the demand for oil, although improving the value of canola meal would provide some opportunity for growth. Production has been increasing in line with growth in canola seed production and substitution of other oils with canola. This study has shown that there is a good opportunity to increase the use of canola meal through increasing inclusion levels, opening new markets and maintaining share in a growing intensive livestock market. It is estimated that with improved information and quality, that an additional 420,000 tonnes of canola meal could be used by the livestock sector.

There are three key areas that create limitations on the use of canola meal, namely:

- Perceptions by end users, nutritionists and millers
- Quality characteristics and anti-nutritional factors
- Testing and measurement capability

Perceptions

Canola is a crop which was developed from rapeseed (5.1). Rapeseed, when used as stockfeed, had various antinutritional problems which were related to low palatability, poor performance and, in some cases, death of stock when fed at high concentrations. In particular, glucosinolates in the meal and erucic acid in the oil were characteristic of rapeseed products. Through plant breeding, particularly in Canada, canola was developed. Canola, although similar in many respects to rapeseed has virtually no erucic acid in the oil and very low levels of glucosinolate in the meal compared to the parent crop. New cultivars also have higher protein contents and better fatty acid profiles.

Despite the new developments, and the name canola to distinguish from the parent crop, perceptions continue that canola may have the same issues as rapeseed. Education can help provide this information but where there are continuing doubts, research trials and feeding trials may be required to clear the issues.

Quality characteristics

Australian canola quality is equivalent to any in the countries producing canola. Glucosinolates, erucic acid, fatty acid profiles and other characteristics are at acceptable levels based on international research. Several breeding programs within Australia are continuing to build on this quality to increase oil and protein contents and to alter minor components such as chlorophyll, sinapine and fibre.

Despite the general quality discussed, Australian growing conditions are variable and environmental conditions impact heavily on canola quality. Oil and protein in particularly can vary significantly across sites, cultivars and years. Glucosinolates and fibre have also been shown to vary (Table 5).

In addition to environmental impacts, seed handling and processing can add another dimension to the range of quality on canola products. Poor storage and handling of seed can cause damage to meal and oil. Operating temperatures in oil extraction, seed and meal drying and subsequent handling as discussed in this report can cause improvements or damage to canola by-products.

Priorities developed in this report need to consider these variables and ensure that the canola grown and processed within Australia meets high standards under all conditions.

Testing and measurement

The evaluation of meal for stockfeed needs to be accurate and provide information which utilises the real value of canola meal. If product quality is extrapolated from theoretical figures developed in Canada or alternative sources, safety margins need to be included to ensure adequate allowances for meal components. As such, quality is often undervalued and the product competes with alternatives on an uneven level. NIR has been shown by research and bulk handlers to be rapid, accurate and precise for many plant parameters. Fatty acids and amino acids and other components may also be evaluated by this method with collaboration between research and industry. Although the equipment is expensive, commercial laboratories can supply this data to small scale operations rapidly and at low cost.

Education, R&D and the Influencers

There are many levels at which canola meal quality and use is determined. From breeding programs where quality is designed, through storage and handling associations to crushers and millers who can have major influences on quality. Currently, the major influences of meal inclusion levels would appear to be nutritionists and feed millers. There is also considerable input from consultants and, to some extent, livestock producers. Within these groups there is considerable expertise within specific fields as well as areas of misunderstanding.

Where the information is available, it needs to be communicated to the industry and this would appear to be best organised by the Australian Oilseeds Federation. Experts from the industry should be utilised to develop this database in terms of literature, workshops and other resources.

Breeding programs have made massive changes in converting a traditional crop from rapeseed to canola. The requirements of the industry for an optimum meal product with specific quality characteristics are possible. Continued discussion between all levels of the industry can reduce the limitations and improve the potential.

9. Priorities

The following list of priorities has been developed from an assessment of comments and discussion with the industry. The many levels of the industry and the different requirements of canola meal for different species, including ruminants and monogastrics, make precise recommendations difficult. However, these priorities are provided to allow industry to have an input and an opportunity to make suggestions to help further develop the canola meal industry.

The major areas of interest are listed under the headings of Education, Testing, Quality Characteristics and Other Issues. These were areas where there may be a reasonable to good chance of success. Numerous projects and suggestions were provided although some of these were considered as a low chance of success or low priority. In some cases the outcomes would be met indirectly through the priorities listed below.

9.1 Education

Priority No. 1. Education and Communication

The limitations to increasing canola usage is generally based on a lack of information about quality characteristics. Many of the factors relating to limitations of quality parameters were either based on literature values or perceived understanding of canola meal. Issues such as glucosinolates and erucic acid were not well understood. Several participants had feelings about canola in line with limitations of rapeseed from the past. Many felt that millers had poor feelings about canola and often it was blamed for any ill effects seen in stock. In fact, most of these parameters have been well research either in Australia or overseas, particularly Canada. The need is not necessarily to repeat the research but to disseminate current information.

Responsibility: AOF together with research and industry personnel.

Process: This could include:

- Development of an Industry Expert database to identify possible educators.
- Develop a set of specific courses and literature, using the expert database, to provide information to individual industries on the benefits of canola meal.
- Develop a set of handouts on feed rations, inclusion rates, etc. for each livestock group. This may include a laminated version to go on the shed wall.
- Identify the differences between solvent, expeller and cold pressed meal.
- Develop a database of scientific and industry knowledge (reference library) on the AOF web page for access by the industry.
- Develop a distribution list for annual canola meal newsletter that updates industry on quality, research findings and market outlook.

Priority No. 2. Directions for millers based on outturn quality

Some millers felt they needed some direction based on product quality outturn to help formulate rations. The available amino acids and by-pass protein together with NDF/ADF fibre ratios need an education program and perhaps formulation charts to simplify formulation.

Responsibility: AOF

Requirement: Education program for millers and formulators. Development of charts with inclusion levels and limitations based on product quality.

9.2 Testing/standards

Priority No. 3. Measuring amino acids value:

Most formulations are based on estimated or perceived values of canola meal amino acid content. Analysis of amino acids is costly and time consuming and currently is not possible on a batch to batch process. Actual available amino acid is based on a range of methods with varying levels of correlation to animal performance including NDIN, Slope ratio chick assay, NIR, KOH. Preliminary studies using rapid NIR spectroscopy has shown a potential to measure total, reactive and reverted lysine against pig performance. It may also be possible to calibrate for other amino acids. Global NIR calibrations for amino acids would allow canola meal to be utilised at maximum value.

Responsibility: Researchers

Requirement: Research should be carried out to determine the possibility of calibrating NIR to provide true amino acid value to nutritionists. This should be done in such a way that the calibrations are freely available to Australian stockfeed manufacturers to ensure utilisation.

Priority No. 4. AOF Quality Standards

Current AOF Trading standards include levels for crude protein and crude fibre although these criteria have little true meaning for feed formulations. Crude protein is used as an indicator to estimate available amino acids and relies on conversion formulas based on estimated heat damage during crushing and pelletizing. ADF/NDF fibre is more useful for nutritionists. New quality standards need to be established for NDF and ADF fibre and for digestible and available amino acids,

Requirement: AOF Standards Committee

Requirement: Standards need to be added to the AOF Standards Manual for ADF, NDF and amino acid values, in addition to the current standards for crude protein and crude fibre.

9.3 Quality characteristics

Priority No 5. Consistency in crude protein content:

Inconsistent quality was seen by many participants as one of the main problems with determining the real value of canola meal. The first level of variability relates to environmental variation which results in oil contents of 35-50% oil content and 32-40% crude protein. Previous discussions with the AOF indicated that there is some potential to overcome this at the grain receival stage, blending seed from good and bad performing sites.

Responsibility: Crushing plants; Bulk Handling Authorities

Requirement: Protocols need to be explored to assist in blending high and low oil batches of seed to achieve a consistent oil and crude protein content.

Priority No 6. Consistency in outturn quality:

If there is a range in quality, feed millers and end users will value the product at the lowest level of the range. This undervalues canola meal against more uniform products. It would appear that there is considerable variation between plants, including solvent and expeller plants due to different heating regimes (time x temperature x moisture content). Additionally there are misconceptions about the role heating plays in creating the optimum feed quality (ratio of by-pass protein to digestible protein).

Responsibility: Research; crushing plants; feed millers; feed evaluation trials

Requirement:

1. A survey should be carried out to determine the outturn quality and the variation between canola meals from different crushing plants over a period of time. This will help identify the degree of variation within and between crushers and will provide millers with better data on the quality of Australian meal.
2. The optimum cooking conditions need to be determined by research studies to produce the best meal quality. This would allow for solvent to be adequately removed in the Desolventizer/Toaster process during oil extraction using the best time/temperature/moisture conditions with minimal heat damage. It will then determine maximum cooking times and temperatures to achieve optimum protein/amino acid quality.
3. This would include feeding studies of meal protein to ensure the minimum damage to the meal and the best value product. This will allow the industry to develop benchmarks on product quality for each process. Crushers, millers and feed evaluation units have all shown interest in being involved in such a study. Once established, the protocol would be provided to processors to allow them to optimise their own conditions. Overall, this should see a more uniform product across the industry.

Priority No. 7. Sinapine content

Although some participants felt canola meal had no problem with palatability, more than half commented that stock would select around it and avoid it where possible. It is of most importance to the poultry industry where sinapine levels are the major restriction for egg layers due to egg taint. Breeders need to screen for sinapine and produce cultivars with considerably less than currently available. At 1.5% sinapine it appears acceptable at current inclusion rates. The poultry industry feels that the inclusion rate could double. That indicates that sinapine levels need to be reduced to half of the current levels i.e. 0.75%.

Responsibilty: Breeders

Requirement: Calibrations should be established for NIR screening of sinapine from breeding trials. The data generated should be utilised to select for new cultivars with an aim to have less than 0.75% sinapine.

Priority No. 8. Glucosinolates

Glucosinolates have been reduced from the original Brassica napus cultivars such as Jumbuck and Bunyip which were around 110 µmols/g to current levels in Oscar of 5-10 µmols/g in seed at 6% moisture. Further reductions, preferably zero, are essential for the crushing industry and for poultry, fish and pet food industries. Cattle and pigs seem not to be concerned with glucosinolates.

Sulphurous odours at crushing plants are a major environmental problem and may ultimately see crushing plants closed or need to be relocated from major cities. The removal of sulphur containing glucosinolates, which release isothiocyanates on hydrolysis, is critical for the industry.

Responsibility: Breeders

Requirement: Breeding programs need to re-evaluate programs to see glucosinolate reduction to zero values become a priority.

Priority No. 9. Fibre - NIR screening fibre and carbohydrates

Current fibre levels are presented in Table 9. These levels are too high for all of the individual industries and needs to be reduced. The level of fibre will be reduced by breeders if they can obtain data from breeding trials. These involve large numbers of samples and this can only be achieved by NIR analysis.

Responsibility Breeders, researchers

Requirement: Breeding programs need to re-evaluate programs to see fibre reduction to acceptable levels become a priority.

Priority No. 10. Colour

Colour was a major priority for pet food manufacturers, but it was also clearly of importance to other stockfeed millers. The meal, even with black seed coats, comes from the solvent extraction process in a light colour with black specks. However, the addition of gums and toasting darkens the colour to create a brown to chocolate brown colour, sometimes with a burnt odour.

Responsibility: Crushers

Requirement: Further to Priority 1, temperature, time and moisture content need to be optimised to produce minimal damage to meal quality.

9.4 Others

Priority No. 11. Biosecurity

The poultry industry see that the possible contamination of canola meal with microrganisms such as salmonella as possibly their biggest fear in using canola meal. To overcome the possibility of contamination the meal is heated during processing and again by the millers during pelletizing. This treatment is likely to cause further damage to protein.

Responsibility: Crushing plants

Requirement: Crushing plants need to determine the source of contamination and take steps to prevent it. It appears that it may be caused by either birds (particularly pigeons) and by rodents. Methods to determine the source may require the services of microbiological personnel.

Priority No. 12. Segregation and Bonification

Feed millers see value in canola meal with high protein content. Currently meals are being sold at a premium in Eastern Australia due to the high protein levels and as a result of generally low oil content. In WA, there were comments regarding the poor quality of the meal due to low proteins of 33%, again likely the result of high oil contents experienced in that state in recent years. Despite the value of the protein, farmers receive no benefit for canola crops with high protein and will more likely receive a reduced return on their crop for low oil content. The potential exists for benefiting two markets by segregation of low oil/high protein from high oil/low protein crops. This may be possible based on selection of seed from areas of the country dependant on environmental conditions in particular years.

Responsibility: AOF, Bulk Handlers

Requirement: Crushers and bulk handling authorities need to consider the best methods of rewarding growers for high protein crops and directing those products to the feed industry.

Priority No. 13. Provide direction to breeders to ensure uniform aims to suit industry:

There is some feeling that there is a void between the aims and priorities of breeders and the needs of industry. Breeders feel that it requires different sectors of the industry to agree what those requirements are i.e. monogastrics and ruminants have different requirements.

Responsibility: AOF, Research Organisations, GRDC

Requirement: This may require industry to set priorities for breeding programs. It might be done through the AOF End-user group or through government regulation.

9.5 Additional aims with lower priority:

i) Altered amino acid content – The potential to achieve this by breeding is low and would be associated with high cost. Addition of synthetic amino acids may be a better alternative.

ii) Improved drought tolerant and insect tolerant cultivars – This is already an aim of the breeding programs and cultivars are currently being developed to suit the northern areas of NSW and Southern Queensland.

iii) Choline levels in canola – This may have some chance of success and could be incorporated into studies on sinapine and choline esters.

iv) Yellow seeded canola – Yellow seediness is important for meal colour but currently the majority of colour is contributed by overheating meal in the extraction process. Other issues of lower fibre and higher oil/protein in yellow seeded types need to be verified.

10. Additional Reading

General

Bell, J.M. 1993. Factors affecting the nutritional value of canola meal: a review. Can. J. Anim. Sci. 73:679-697.

Summers, J.D., D. Spratt and M. Bedford. 1992. Sulfur and calcium supplementation of soybean and canola meal diets. Can. J. Anim. Sci. 72:127-133.

Hickling, D. 2003.Canola Meal – Feed Industry guide. Canola Council of Canada. www.canolacouncil.com

Bell, J.M. and M.O. Keith. 1991. A survey of variation in the chemical composition of commercial canola meal produced in western Canadian crushing plants. Can. J. Anim. Sci. 71:469-480.

Aquaculture

Glencross, B., Hawkins, W. and Curnow, J. 2004. Nutritional assessment of Australian canola meals. Evaluation of canola oil extraction method and meal processing conditions on the digestible value of canola meals fed to red sea bream. Aquaculture Journal. 35:15-24.

Allan, G.L., Parkinson, S., Booth, M.A., Stone, D.A.J., Rowland, S.J., Frances, J., Warner-Smith, R., 2000. Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus*: I. Digestibility of alternative ingredients. *Aquaculture* 186, 293-310.

Allan, G.L.,, Rowland, S.J., Mifsud, C., Glendenning, D., Stone, D.A.J., Ford, A., 2000. Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus* V. Least-cost formulation of practical diets. *Aquaculture* 186, 327-340.

Allan, G.L. & Booth, M.A. (in press). Effects of extrusion processing and dehulling on digestibility of extruded peas, lupins, soybean and canola in silver perch *Bidyanus bidyanus*) diets. *Aquaculture Research*.

Allan, G.L., Rowland, S.J., 1994. The use of Australian oilseeds and grain legumes in aquaculture diets. In: L.M. Chou et al (Eds.), Proc. Third Asian Fisheries Forum, October 26-30, 1992, Singapore. Asian Fisheries Society, Manila, Philippines, pp. 667-669.

Dairy

Feeding standards for Australian Livestock. Ruminants: CSIRO, Australia ISBN 0 643 04314 6. CSIRO Printing Centre, Collingwood, Victoria.

Ha, J.K. and Kennelly, J.J.. 1984. In situ dry matter and protein degradation of various protein sources in dairy cattle. Can. J. Anim. Sci. 64:443-452.

Moran, J. 1997. Improving supplement quality for cows in early lactation. Final Report – AOF, Wilberforce.

Lambs

Mandiki, S.N.M., J.L. Bister, G. Derycke, J.P. Wathelet, N. Mabon, N. Marlier and R. Paquay. 1999. Optimal level of rapeseed meal in diets of lambs. Proceedings 10th International Rapeseed Congress, Canberra, Australia, 1999.

Pigs

Feeding standards for Australian Livestock. Pigs: CSIRO, Australia ISBN 0 643 04313 6. CSIRO Printing Centre, Collingwood, Victoria.

Heartland Lysine. 1998. Digestibility of essential amino acids for poultry and swine. Version 3.51. Heartland Lysine Inc., Chicago, IL. www.lysine.com

King, R. 2000. Canola meal for pigs. Pig Research Report -DV174/1543V1, Pig Research and Development Corporation, Canberra, Australia.

King, R. 2001. Pathways for nutritional information. Pig Research Report -DV1638, Pig Research and Development Corporation, Canberra, Australia.

van Barneveld, RJ. 1998. Influence of oil extraction method on the nutritional value of canola meal for growing pigs. Final Report DAS38/1188. Pig Research and Development Corporation, Canberra, Australia

van Barneveld, RJ. 2001. Rapid prediction of reactive lysine in heat-processed feed ingredients used in pig diets. Final Report No. 1603. Australian Pork Limited, .

van Barneveld, RJ. 2004. Development of the Australian livestock feed ingredient (ALFI) database. South Australian Research and Development Institute, www.sardi.sa.gov.au. 2001.

Poultry

Bryden, W.L. and Li, X. 2004. Utilisation of digestible amino acids by broilers. RIRDC Report 04/030. Rural Industries Research and Development Corporation. Canberra, Australia.

Feeding standards for Australian Livestock. Poultry: CSIRO, Australia ISBN 0 643 04312 8. CSIRO Printing Centre, Collingwood, Victoria.

Perez –Maldonado, R. 2003. How much cottonseed and canola meal can be used in commercial broiler diets? 2004 World Poultry Congress, Turkey.

Perez-Maldonado, R. 2002. Characterisation of canola meal and cottonseed meal at practical inclusion levels for use in broiler and layer diets. RIRDC Report Project No. DAQ-264A.

Perez-Maldonado, R. 2003. Developing a slope ratio chick assay for amino acid availability. RIRDC Report Project No. DAQ-277A.

Ravindran, V., Hew, L.I., and Bryden, W.L. 1998. Digestible amino acids in poultry feedstuffs. RIRDC Report no. 98/9, Project US-67CM, Rural Research and Development Corporation, Canberra, Australia.

Slominski, B.A. and L.D. Campbell. 1990. Non-starch polysaccharides of canola meal: Quantification, digestibility in poultry and potential benefit of dietary enzyme supplementation. J. Sci. Food Agric. 53:175-84.

Summers, J.D., D. Spratt and M. Bedford. 1990. Factors influencing the response to calcium supplementation of canola meal. Poult. Sci. 69:615-622.

Others

1. End User Report, AOF. August 2000
2. AOF End User Minutes, AOF. April 2001
3. End User Action Sheet, AOF. June 2003

ANNEX

Questions for the Survey

For processors, feed manufacturers, consumer industries (pigs, poultry, dairy, etc.)

1. How much canola is used in this industry?
2. What are the substitutes for canola meal
3. What are inclusion levels for canola meal and what drives this i.e. at what quality specification do they factor canola meal in at
4. What are the critical quality criteria important to your industry
5. Is there a change in usage (up or down) and how much? How have these changed and why
6. What are the limiting factors in canola meal usage in this industry? What value do these factors have
7. What is the potential usage or expected production trends or livestock numbers in your industry
8. What needs to be changed in canola meal to reach that potential? What strategies do they have to overcome limitations eg synthetic amino acids etc
9. What projects could/would you propose to improve the situation? What questions regarding use of canola meal remain unresolved
10. How would the outcomes be utilised?
11. Who would benefit by the developments?
12. What is the chance of success?
13. Who might contribute funding to these types of projects?

For crushers

1. What steps in meal production process do they believe influence meal quality
2. What are your quality benchmarks
3. What information is there on the quality of canola meal produced? Actual quality of product out-turned
4. How is this related to seed quality – GxE (expand)
5. How much canola meal is produced, exported, consumed?
6. Feedback they receive from end users re deficiencies
7. How end users assess canola meal value
8. What they see as the major needs
9. Adequately describe canola raw material quality (seed)
10. Production process
11. Defining benefits for end users
12. How would we do a study on processing – (need 5 tonnes for cattle).

List of Participants in Survey

	COMPANY	NAMES	OCCUPATION	LOCATION
1. Marketers				
	Graincorp	Simon Clancy Cameron Pratt	Commodity Trader	Sydney NSW
	Riverland Oilseed Processors	Clint, Munro Daniel Sinclair		Sydney NSW
2. Crushers				
	Cargill	Denis M'Gee	Tech Services Mgr	Newcastle, NSW
	Cargill	Alan Thompson	Plant Chemist	Melbourne, VIC
	Cargill	Jody Scaife	Sales & Marketing	Melbourne, VIC
	Cargill	Rolfe Buehlter	Plant Mgr	Melbourne, VIC
	Riverland Oilseed Processors	Randolph Sidoo	General Mgr	Numurkah, VIC
	Riverland Oilseed Processors	Jon Slee	Marketing Mgr	Perth, WA
	Cootamundra Oilseeds	Geoff Black		Cootamundra, NSW
	Mac Smith Milling	Peter MacSmith		Orange, NSW
3. Feed Manufacturers				
	Weston Nutrition	Todd Middlebrook	Nutritionist	Enfield, NSW
	QAF Meat Indust.	David Henman	Manager, Nutritional Services	Corowa, NSW
	Coprice Feed Mill	Paul Groves	Tech Advisor	Cobden, VIC
	Ridley AgriProd.	Neil Gannon	Technical Services Manager	Toowoomba, QLD
	Milne Feeds	Dr Jenny Davis	Nutritionist	Perth, WA
	Poultry Farmers WA Coop	Richard Beck Javed Hayat	Inventory Manager Tech Services Manager	Perth, WA
	Wesfeeds	Daniel Goussac	Technical Mgr	Perth, WA
4. Beef				
	NSW DPI	Alan Kaiser	Research	Wagga, NSW
	ALFA			Sydney, NSW
5. Dairy				
	Bovine Services	Ian Lean	Consultant	Camden, NSW
	Best Fed Nutrition	Les Sandles	Nutritionist	Shepparton, VIC
	Parmalat	Iain Hannah	Supplier Development Officer	South Brisbane, QLD
	Q.D.P.I.	Danny Barber	Research – Dairy	Brisbane, QLD
	Dairy Farmers	Trevor King	Nutritionist	Orange, NSW
	Murray Goulburn	Cameron Smith		Melbourne, VIC
6. Pigs				
	NSW DPI	Roger Giles	Research	Camden, NSW
	NSW DPI	Chris Brewster	Research	Yanco, NSW
	Vic. DPI	Ray King	Research Director	Werribee, VIC
	Australian Pork	Ian Johnsson	General Manager	Deakin West, ACT
	NSW Agriculture	Greg Roese		Tamworth, NSW
7. Poultry				
	Inghams	Geoff Clatworthy	Nutritionist	Leppington, NSW
	Inghams	Richard Sevil	Manager	Newcastle, NSW
	Poultry, QDPI	Perez-Maldonado Danny Singh	Research	Cleveland, QLD
	Univ of Qld	Rafat Aljassim	School of Animal Studies	Gatton, QLD
8 Aquaculture				
	NSW Fisheries	Geoff Allan	Research	Nelson Bay, NSW
9. Pet Food				
	Uncle Ben's	Shane Walsh	Nutritionist	Wodonga, VIC
10. Canola Breeding				
	NSW DPI	Neil Wratten	Breeder	Wagga Wagga NSW
11. Economics				
	NSW DPI	John Brennan	Economist	Wagga Wagga NSW