The influence of processing conditions on the nutritive value of canola meal

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Canola production in Australia

Australia produces around 1.5 million tonnes of canola annually. In 2005 the canola harvest at 1,438,750 tonnes from 960,000 hectares was slightly lower than 2004. The yield varied from a state average of 1.4 t/ha in Western Australia (WA) to 1.8 t/ha in New South Wales (NSW). The national average yield is around 1.5 t/ha. Around 400,000 tonnes is crushed producing around 240,000 tonnes of meal. The meal produced is classified as expeller or solvent extracted meal with approximately 85% of the meal processed being solvent extracted. Mechanically extracted expeller meal contains around 10% oil whereas solvent extracted meal has around 1%.

Australian Canola Quality

Australian canola is grown over a vast range of environments from northern NSW to the southern parts of WA. As a result there is a significant range in quality, particularly for oil and protein contents. Fatty acid profiles, chlorophyll levels, free fatty acids and other oil characteristics can also vary with growing conditions. The average quality of Australian canola is presented in Table 2.

Table 1: Average quality data of Australian canola seed 2005 (McFadden, et al. 2005)

Quality Parameter	Mean
Oil content, % in whole seed @ 6 % moisture	42.2
Protein content, % in oil-free meal @ 10 % moisture	36.3
Glucosinolates, µmoles/g in whole seed @ 6 % moisture	7
Volumetric grain weights (kg/hL)	64.1
Oleic acid concentration (C18:1), % in oil	60.9
Linoleic acid concentration (C18:2), % in oil	19.9
Linolenic acid concentration (C18:3), % in oil	10.8
Erucic acid concentration (C22:1), % in oil	0.1
Saturated fatty acid concentration, % in oil	7.0
Iodine Value	116.2

Canola meal is well recognised as a high protein source for use in stock feed. The high protein meal has a well balanced amino acid profile. Depending on processing conditions the meal may also contain a substantial amount of high energy canola oil which adds to the meal quality. The amount of oil and the fatty acid profile will be influenced by the method of extraction.

As well as the beneficial components of canola meal, it also has some limitations. Initially rapeseed, from which canola was developed, contained high levels of antinutritional components. Traditional meal, contained up to 150 µmols/g of glucosinolates as well as tannins, sinapine and phytic acid all of which influence meal quality.

Protein Content: The average canola meal protein content in 2005 was 36.3 %. This is relatively low when compared to previous years (Fig1.). Protein concentration has an inverse relationship to oil content with the maximum protein achieved in years when oil content is very low. In 2004, crops were badly stressed with drought conditions producing low oil but very high protein (Fig 1).

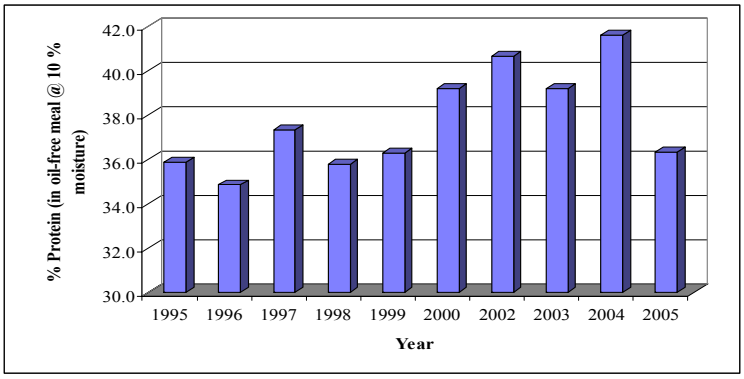


Figure 1: **Australian protein content in canola meal 1995-2005** (McFadden, et al. 2005).

Glucosinolate Concentration: Glucosinolate concentration in Australian canola meal is very low relative to traditional types. In 2005 (McFadden, et al. 2005) concentration ranged from 3 to 12 μmoles/g of total glucosinolates. Some individual sites produce more glucosinolates, particularly under drought stress (Mailer and Cornish 1987).

Processing

Processing canola meal involves several steps each of which contributes to changes in the meal product. The nutritional value of the meal is influenced in particular by temperature, time and moisture. The stages of processing are outlined:

Preconditioning and Flaking: involves preheating the seed and passing it through a roller mill to physically rupture the seed coat without damaging oil quality.

Seed cooking: Cooking thermally ruptures the remaining oil cells at around 90°C. This serves to inactivate myrosinase enzyme and additionally adjust the moisture content for better oil extraction. The time taken is usually around 20 minutes and temperatures are between 80-105°C. Temperatures up to 120°C may be utilised to remove glucosinolates which otherwise impart an odour to the oil.

Pressing: Screw presses or expellers are used to physically squeeze the oil from the canola seed flakes. Around 60-70% of the oil is extracted but care needs to be taken not to damage the meal or presscake.

Solvent extraction: Presscake is solvent extracted to remove the remaining 15-20% oil using hexane. The solvent or miscella (oil and solvent) is sprayed onto the presscake and allowed to percolate through, removing the oil. The remaining meal with less than 1% oil and saturated with solvent is called marc.

Desolventising/Toasting: This process removes solvent from the marc using steam. The last stage of drying is done with dry heat of around 105°C. After about 20 minutes in the D/T process the meal contains around 1% oil and 15% moisture. Moisture content is adjusted to around 10% before transporting to storage containers.

Changes to meal quality

Protein: Meal quantity and quality are affected by various factors from growing, maturity and harvest but the major influences occur during processing. Excessive heating in particular can result in damage to protein and amino acids and reduced digestibility of amino acids, particularly lysine. This protein is referred to as by-pass protein. By reducing the protein digestibility this can benefit ruminants by allowing the protein, which may be lost in the rumen, to stay intact until it reaches the true stomach. However, it is necessary to control conditions to produce by-pass protein without protein degradation.

Crude fat: The oil content of the meal is important as it provides energy to the meal. The oil content varies depending on the method of extraction. Solvent extraction produces meal with around 1% oil whereas expeller may contain up to 12% oil. Cold press meal will contain even higher levels. Despite the increased value to the meal, it is uneconomical for the processor to leave oil in the meal as there is no premium paid for the oil content.

Because cold pressed meal has more oil than solvent extracted oil this results in other changes in meal components. It therefore has lower protein than expeller or solvent extracted meal and higher bulk density than solvent extracted meal due to the extra oil.

Glucosinolates: Processing temperatures can be adjusted in the early stages of processing to inactivate endogenous myrosinase enzyme which otherwise breaks down glucosinolates. If the seed is ruptured in the presence of moisture, glucosinolates will be rapidly decomposed releasing isothiocyanates, thiocyanates nitriles and oxazolidinethione. These by-products influence both meal and oil quality. Enzyme deactivation is achieved by heating the seed at 10% moisture to 80-90°C. The majority of glucosinolates remaining after oil extraction are removed by high temperature in the D/T process although the temperature needs to be controlled to avoid other damage to the meal. Glucosinolates are higher in cold pressed meal than in solvent extracted meal although glucosinolates are generally low compared to traditional canola and rapeseed.

Lysine loss: Amino acid digestibility is reduced through high temperature treatment of canola meal. There is considerable evidence to show that the method of meal processing has a major effect on lysine availability to stock. This is illustrated in Table 3 (van Barneveld, et al 1999). Availability of lysine in particular is reduced in the D/T process. Temperatures of 105°C which are commonly used (Newkirk and Classen 2000) significantly reduce crude protein and lysine

digestibility and reduce metabolizable energy.

Table 3. Comparison of extraction methods on canola meal composition

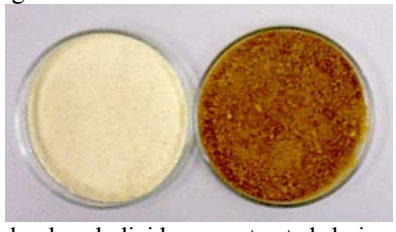
	Ingredient (g/kg)				
Nutrient	solvent extraction	expeller extraction	cold pressed	Seed	Seed (QAC)
Dry matter	882.1	951.3	913.3	949.1	940
Gross energy	177.5	206.0	227.1	272.0	
Crude protein	333.1	325.1	265.4	200.5	208.8
Crude fat	44.8	130.2	255.5	397.2	422
Crude fibre	126.8	148.6	156.5	165.9	
NDF	258.4	329.8	312.4	478.4	
ADF	162.7	234.9	186.0	383.5	
Ash	62.6	57.0	46.9	34.3	
Glucosinolates	1.4	3.0	11.1	9.8	7

Adapted from van Barneveld (1998) and McFadden et. al. (2005).

Table 3. The effect of processing on lysine availability in canola meal (adapted from van Barneveld et. al. 1999).

	Cold-pressed	Expeller	Solvent
Total Lysine	17.41	17.25	18.70
Reactive lysine	13.00	10.88	11.38
Reverted lysine 'loss'	25.30	36.90	39.10

Colour: Some feed manufacturers prefer a light coloured meal. High cooking temperatures at high moisture levels can cause significant darkening of canola meal. Temperatures above 110ºC did not cause significant changes to colour in dry meal in this study but considerable darkening occurred in meal with 10% moisture.



Gums and Soapstocks: Gums include phospholipids are extracted during crude oil degumming and soapstocks are recovered during alkali refining to remove free fatty acids. These compounds are often added back into the meal after the D/T process at around 1-2%, increasing the oil content and the metabolizable energy. It also helps to dampen the meal.

Tannins: Tannins include a range of products including sinapine. Sinapine has been found to cause undesirable flavours in eggs from poultry fed canola meal. Australian canola contains around 0.6 – 1.8% sinapine (unpublished results).

Minerals: are not influenced by methods of processing other than where gums or supplements are added back to the meal after processing.

Table 4. Amino acids showed little variation between processors (Rider Perez 2002)

Analysis	Newcastle solvent	Melbourne Solvent	Numurkah solvent	Pinjarra expeller
Dry matter %	90.5	89.2	89.6	90.2
Crude protein	414	419	418	335
Phosphorus	12	11.5	11.1	10.9
Calcium	8.4	7.0	6.8	7.5
Sulphur	7.0	7.2	7.0	7.0
Fat	49.4	30.7	55.4	129.3
Free condensed tannins	34.2	31.3	38	35.6
Bound condensed tannins	10.1	4.8	24	5.2
Total tannins	44.3	36.1	62	41.8
Sinapine	11.8	12.7	14.8	14.0
Glucosinolates (µm/g)	2	4	3	7
NDF	327.1	285.9	321.4	248.3
Layer hen AME (Mj/kg DM)	11.0	10.6	11.2	11.1
Layer hen AMEn	10.4	9.7	11.1	10.9
Broilers AME (Mj/kg DM)	8.7	9.2	9.7	11
Broilers AMEn	7.6	8.5	8.6	10.4

AME apparent metabolisable energy

Summary: Considerable work has been carried out in Canada and some in Australia on meal quality. However, canola meal is underutilised in Australia due to limited knowledge about the product quality. New data on processing effects

on meal quality are currently being accessed from processors throughout Australia and this will be presented at the 12th International Rapeseed Congress.

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