2. Grain quality

Rod Mailer, NSW DPI

Rapeseed and canola both belong to the family Brassicaceae, genus *Brassica*. Canola was developed from rapeseed to produce an oilseed crop with improved nutritional composition. The aim was to produce a crop which had low levels of glucosinolates in the meal and low levels of erucic acid in the oil. Canola oil must contain less than two per cent erucic acid as a percentage of total fatty acids and the glucosinolate level in the meal must be less than 30 µmol of aliphatic glucosinolates per gram of meal. This equates to about 40 µmol total glucosinolates per gram of meal. Table 2.1 shows the typical chemical composition for canola.

Canola is used in salad dressings, margarines, and bottled oil. It is not ideal for deep frying due to the high level of polyunsaturated fatty acids which make it prone to oxidation. It is often blended with other oils, such as olive oil, to enhance its flavour and stability. Canola oil has the lowest level of saturated fatty acids and is second only to olive oil in its high level of monounsaturated oleic acid. Nutritionists agree that mono and polyunsaturated fatty acids are preferable to saturated animal and tropical plant fats (such as palm). Vegetable oils, including canola, are also recommended over animal fats for their lack of cholesterol.

Several types of canola are being developed for different end-uses. These include types with high levels of lauric, stearic or oleic acids, which can be used for detergents, solid margarines or shortening and cooking oils. Other modified canola types with petroselinic and ricinoleic acids may be used for plastics, lubricants and pharmaceuticals but not for human consumption. These new types will need to be given different names so that there is no confusion about the end-products.

HIGH OLEIC, LOW LINOLENIC ACID CANOLA (HOLL)

HOLL is one of the modified canola types discussed above. Traditional canola has about 62 per cent oleic acid, 20 per cent linoleic acid and nine per cent linolenic acid. Oleic acid is monounsaturated and relatively resistant to oxidation, while linoleic and linolenic acids are polyunsaturated. The more unsaturated the oil, the faster it will oxidise and become rancid.

Linolenic acid, in particular, with three double bonds in the carbon chain, oxidises quickly and therefore makes canola oil unsuitable for high temperature applications such as deep frying.

To make canola more versatile and extend its applications for cooking, HOLL has been produced as an alternative form of canola with higher levels of monounsaturated oleic acid and lower levels of linoleic and linolenic acids. The first of these oils in Australia was marketed by Nutrihealth Pty Ltd under the trade name Monola™.

Monola™ looks like canola, and is managed in the same way, but its fatty acid profile has been changed through conventional plant breeding techniques. It is more expensive than canola oil but can be used for extended periods at high temperatures. Monola™ retains the low level of saturated fats of canola and has a good mix of polyunsaturated and monounsaturated fatty acids.

BRASSICA JUNCEA

Traditional canola cultivars have the characteristic chemical composition shown in Table 2.1, although this may vary slightly between cultivars and due to the influence of environmental conditions. In recent years, *Brassica juncea* has been bred to produce an oil with a fatty acid profile similar to that of canola with low erucic acid and a low concentration of glucosinolates in the meal.

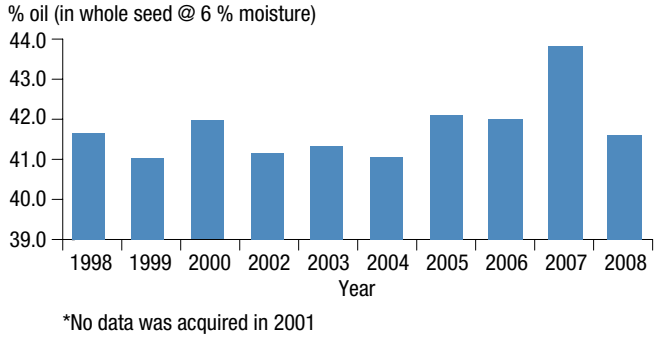
B. juncea is also considered to have characteristics such as drought tolerance which will make the crop more suitable for marginal growing areas of canola. The oil will be used in the same way as *B. napus* canola and the two products may be blended.

Table 2.1 Typical quality parameters of canola, taken from the 2003 canola harvest in Australia*

Quality parameter	Mean
Oil content, per cent in whole seed @ 6% moisture	41.5
Protein content, per cent in oil-free meal @ 10%, moisture (N x 6.25)	39.2
Total glucosinolates, µmol/g meal @ 6% moisture	20.0
Volumetric grain weights, kg/hL	67.7
Oleic acid content (C18:1), per cent in oil	61.5
Linoleic acid content (C18:2), per cent in oil	20.2
Linolenic acid content (C18:3), per cent in oil	9.1
Erucic acid content (C22:1), per cent in oil	0.1
Saturated fatty acid content, per cent in oil	7.6
Iodine value	112.9

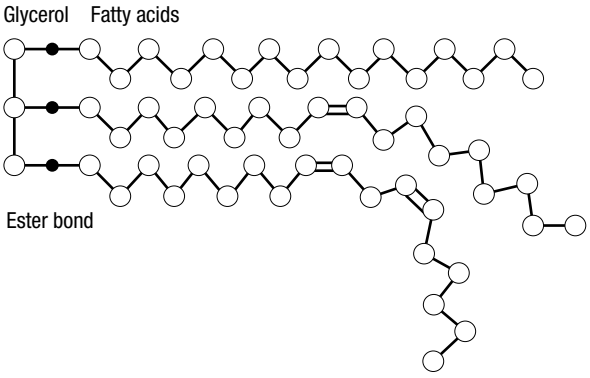
* Samples provided by bulk handling companies in NSW, Victoria and South Australia

Figure 2.1 Variation in average oil content in Australian canola 1998–2008



*No data was acquired in 2001

Figure 2.2 Structure of triacylglycerol molecule in vegetable oil



SOURCE: Meadow Lea

OIL CONTENT

Canola is grown primarily for oil and the value of the oil to the industry has been illustrated by the introduction of a bonus payment to growers for high oil content. A basis of 42 per cent oil content has been determined for the Australian industry and crops attract a bonus of 1.5 per cent for every percentage point above that level. A similar penalty rate applies for crops with oil content below 42 per cent. As a result, oil has been the major priority for breeding programs.

The amount of oil may vary between cultivars and, even more so, between environments and seasons (Figure 2.1). Plant breeders have worked for several years to improve oil content and increase total oil yield per hectare. There is a desire to develop drought resistant types which will produce reasonable oil content even under periods of water stress. The oil content in Australian crops can vary from as low as 30 per cent to slightly above 50 per cent.

Several studies have investigated the reasons for variation in oil content, including water and heat stress, sulfur and nitrogen availability, genotype and site effects. The range of low oil content across growing sites appears to relate strongly to areas of low rainfall and water stress.

Oil content is determined by solvent extraction (Goldfische) or by the use of near infrared (NIR) instruments which have been calibrated against solvent extraction methods. The oil content is expressed at 6 per cent moisture basis. Although the moisture may vary depending on atmospheric humidity, six per cent approximates the average moisture content of canola delivered to grain terminals.

FATTY ACID PROFILES

Triacylglycerols

Edible oils are composed of fatty acids, which are contained in structures called triacylglycerols (sometimes called triglycerides). Each triacylglycerol contains three fatty acids. If fatty acids are liberated by enzymatic (lipase) activity they become free fatty acids which are undesirable products in the oil. As well as the three fatty acids, each oil unit contains a glycerol molecule (Figure 2.2). If one fatty acid is removed, it becomes a diacylglycerol (diglyceride) and if two are removed it is a monoglyceride.

Fatty acids

Common oilseeds contain 13 significant fatty acids and many more minor ones. Fatty acids are long chains of carbon atoms, which differ from each other by the number of carbons (from 14 to 24, Table 2.2). The other difference between fatty acids is the presence or absence of one or more double bonds between the carbon atoms (Figure 2.3). If there are no double bonds, the fatty acid is said to be saturated. If there is one double bond it is monounsaturated. Fatty acids that contain two or more double bonds are polyunsaturated.

The number of double bonds and the length of the chain determine the characteristics of the fatty acid. Saturated fatty acids have much higher melting points than unsaturated ones. For example, oleic acid with one double bond melts at 4°C, whereas saturated palmitic acid melts at 64°C.

Table 2.2 Typical fatty acid profile of canola oil

Fatty acid	Trivial name	Percentage
14:0	Myristic	0.1
16:0	Palmitic	4.7
16:1	Pamitoleic	0.4
18:0	Stearic	2.4
18:1	Oleic	62.2
18:2	Linoleic	19.7
18:3	Linolenic	8.5
20:0	Arachidic	0.5
20:1	Gadoleic	1.0
22:0	Behenic	0.2
22:1	Erucic	0.1
24:0	Lignoceric	0.1
24:1	Nervonic	0.1
Saturated fats		8.0
Iodine value		111.0

ERUCIC ACID

The level of erucic acid has a major influence on the fatty acid content of canola. Erucic acid is a long carbon monounsaturated fatty acid which has been shown to be nutritionally undesirable in studies with poultry. On the basis of these tests the maximum limit for erucic acid was set for Canadian canola at two per cent. This was also the limit set in the UK for low erucic acid rapeseed (LEAR) and for European rapeseed (for example colza). Since the introduction of canola, plant breeding programs have continued to select for lower levels of erucic acid such that current cultivars are now generally less than 0.5 per cent.

IODINE VALUE

Iodine value is a measure of the degree of unsaturation in fats and oils expressed as the number of grams of iodine which will react with 100 g of fat. This can be determined by iodometric titration (Australian Oilseeds Federation (AOF) 4–2.20). However, it is generally determined by using the fatty acid profile determined by gas chromatography and then applying a simple formula to calculate iodine value. The higher the iodine level, the more unsaturated is the fat and the less stable it will be to oxidation. This would indicate which oils are more stable for cooking or for longer shelf life.

CHLOROPHYLL CONTENT

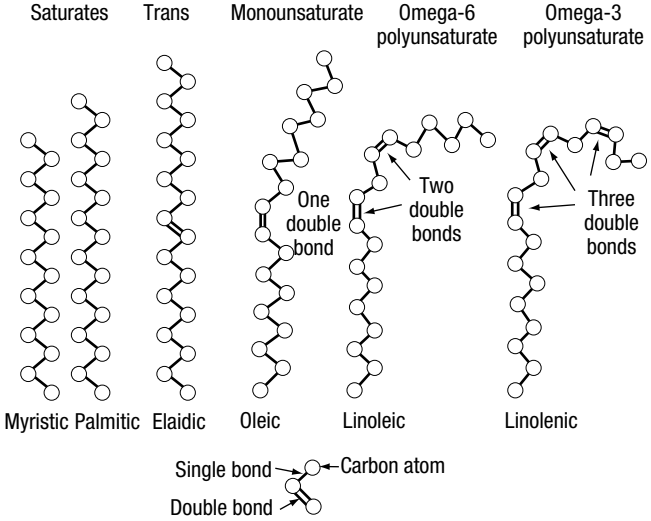
The green colour in plants is due to the pigment chlorophyll. As plants mature, the chlorophyll breaks down to alternative pigments such as pheophytins and the colour changes from green to yellow or brown. However, chlorophyll in canola seeds can be trapped in the seed cotyledons if the seed is killed by sudden stress such as frost damage or water stress. The green colour is then preserved and will persist for years in intact seed.

When oil is extracted from green seeds the chlorophyll is transferred to the oil, resulting in green oil. Although green olive oil is acceptable, in canola oil, a green colour is considered to be undesirable. Removal of chlorophyll is both expensive and time consuming and therefore incurs a penalty at the point of sale of the seed to the bulk handling companies.

The AOF Technical and Quality Standards has set a maximum standard for delivered seed of two 'distinctly green' seeds per 100. This is determined by taking 100 seeds applied to masking tape, crushing them with a paint roller and counting the seeds with green cotyledons. This test is recognised as an indicator of chlorophyll content although it is not very accurate. A more accurate measure is to extract the chlorophyll from seeds and measure it with a spectrophotometer (AOF method 4–1.20) or by high performance liquid chromatography.

It is difficult to predict the final colour of extracted oil by measuring chlorophyll in the seed. Chlorophyll changes under the influence of heat and light and it is likely that the colour will be less intense after processing the seed. However, a high reading of chlorophyll in the seed should indicate to the processor that chlorophyll and pheophytins will be present in the oil.

Figure 2.3 Structure of the common fatty acids present in canola oil



Hydrogen atoms are attached to the carbon atoms but are not shown in this diagram

SOURCE: Meadow Lea

CANOLA MEAL

The seed residue remaining after the oil has been removed is referred to as the meal or flour. This by-product of canola is relatively high in protein, vitamins and minerals and is commonly used for animal feed.

Canola has a good amino acid profile and mid range fibre content. It is generally considered that the by-pass protein of canola is suitable for ruminants although some nutritional consultants consider that it lacks rumen degradable protein. Meal quality, including moisture, crude protein and oil content, varies over successive years and in different environments. Table 2.3 includes data on canola meal nutrient composition. Processing conditions may further influence the range in the final quality of these parameters.

PROTEIN

The protein content of canola meal, like the oil content, varies between sites, cultivars and seasons (Figure 2.4). Protein content is determined by a method of combustion referred to as the Dumas technique. This method is commonly performed using a Leco nitrogen analyser although other instruments are also available. The protein content is expressed on a 10 per cent moisture basis, i.e. for seed at six per cent moisture and 42 per cent oil, when the oil is removed, the meal will contain 10 per cent moisture.

The standard for meal protein is a minimum of 35 per cent at 10 per cent moisture. As oil and protein content are

inversely proportional, if oil is low, meal protein will be higher, and vice versa.

A comparison of Figures 2.1 and 2.4 highlights the relationship between oil content and protein content of the meal. Growing conditions that favour high oil generally result in low protein in the meal. The high oil content in 1996 resulted in low protein in the same year. In the past decade, breeders have changed their priorities to select cultivars that are high in both oil and protein. As a result, protein contents have been increasing despite relatively consistent oil contents, as shown in Figure 2.4.

Table 2.3 Canola meal nutrient composition tables

Component	Composition
Moisture (%)	10.0
Crude protein (N x 6.25; %)	35.0
Rumen bypass protein (%)	35.0
Oil (%)	3.5
Linoleic acid (%)	0.6
Ash (%)	6.1
Sugars (%)	8.0
Starch (%)	5.2
Cellulose (%)	4.6
Oligosaccharides	2.3
Non-starch polysaccharides (%)	16.1
Soluble NSPs (%)	1.4
Insoluble NSPs (%)	14.7
Crude fibre (%)	12.0
Acid detergent fibre (%)	17.2
Neutral detergent fibre (%)	21.2
Total dietary fibre (%)	33.0
Tannins (%)	1.5
Sinapine (%)	1.0
Phytic acid (%)	4.0
Glucosinolates (µmoles/g)	16
Bulk density, mash	16 kg/ft^3, 565 kg/m^3
Bulk density, pellets	19 kg/ft^3, 670 kg/m^3

SOURCE: Canola Council of Canada, Feed Industry Guide

Figure 2.4 Average protein content of Australian canola 1998–2008

* No data was acquired in 2001

Proteins are made up of amino acids and the proportions of different amino acids determine the value of the meal for particular applications. The high level of sulfur containing amino acids makes canola meal particularly suitable for poultry diets. The dairy industries also utilise protein meal.

GLUCOSINOLATES

Glucosinolates are chemical compounds present in the meal or flour portion of canola as well as in the green plant material. They are responsible for the crop's cabbage smell and the odour when canola is crushed.

Glucosinolates are a problem for stock fed with canola meal because, in high concentrations, they can affect the animals' thyroid activity and cause goitre. In poultry they have been linked to other nutritional disorders. At current levels, glucosinolates do not appear to cause any problems in feed rations. However, canola breeders are encouraged to further reduce concentrations to enable a greater proportion of meal to be included in animal rations.

Early rapeseed cultivars introduced to Australia, and some subsequent Australian lines, had glucosinolate levels above 100 µmols/g of oil free meal and well above canola standards. Through plant breeding, today's cultivars have very low levels of glucosinolate, generally less that 20 µmols/g meal. Glucosinolate levels vary with growing conditions and, in particular, increase with water stress.

VOLUMETRIC GRAIN WEIGHTS

Grain weight is an indicator of grain quality. Grain that has been stressed during maturity will have low grain weight, generally also reflecting low oil contents. Frost or insect damage may also result in low grain weights. Damaged seed may be high in free fatty acids as well as low in oil content. Volumetric grain weights are measured using a Franklin chondrometer and reported as lbs/bushel and kg/hectolitre. In 2003, grain weights for samples provided to NSW DPI from bulk handling companies averaged 67.7 kg/hl.