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Kellie Winfield

Maurice Hall

Blakely Paynter

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This Bulletin explains the differences between oat products used for human and animal consumption and the importance of the quality parameter to the quality of the end product. It also indicates why different varieties are suited to different end markets.

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Breeding targets

Genotype determines which market a particular oat variety is used for. Management and season determines whether or not the delivered grain of that variety is actually suitable for using for that end product.

Table 1 lists some of the desired attributes required of a variety bred for human consumption (or a milling market) versus a variety bred for animal consumption (or a feed market). Whilst many of the physical characteristics of milling and feed oats are similar, large differences exist in the desired chemical characteristics. For example, oats used for human consumption has a breeding target of high levels of beta glucan whilst oats destined for animal consumption has a breeding target for lower levels of beta glucan.

Unlike other cereal markets, there are no set industry standards for the quality of oat grain for human and animal

Table 1. Breeding quality targets for oat grain destined for human and animal consumption.

Trait	Breeding targets for human consumption (milling)	Breeding targets for animal) consumption (feed
Physical attributes		
Hectolitre weight	High	High
Grain plumpness	High	High
Groat percent	High	High
Grain colour	High	High
Grain brightness	High	High
Grain hardness	High	-
Ease of dehulling	High	-
Chemical attributes		
Grain protein percent	High	High
Oil percent	Low	High
Beta glucan	High	Low
Starch gelatinisation	High	-
Hull lignin percent	-	Low
Taste	Not bitter	-

Figure 1. *(left to right) top – Grain of Carrolup and Mortlock and bottom – Dalyup and Wandering(b oat varieties*

Table 2. Physical and chemical attributes of some Western Australian milling (Mortlock, Carrolup) and feed (Dalyup and Wandering) oat varieties.

TRAIT	VARIETY			
	Mortlock	Carrolup	Dalyup	Wandering
Hectolitre weight (kg/hl)	53.2	53.5	51.5	50.8
Groat yield (%)	73.3	73.1	69.7	72.5
Milling yield (%)	70.2	70.2	66.2	69.6
Ease of dehulling	Good	Good	Poor	Good
Grain protein (%)	12.1	11.1	10.9	10.8
Oil (%)	6.1	6.0	6.0	6.5
Beta glucan (%)	5.1	4.7	5.0	4.8
Seed size (mg)	40	38	37	39

consumption. As a consequence quality standards differ between millers and between feed grain buyers depending on the market they are supplying.

The National Oat Breeding Program (based in Adelaide and Perth) is the largest oat breeding program in Australia. They, like other oat breeding companies, are aiming to breed high yielding, disease resistant oat varieties for human and animal consumption targeting the high attributes required for each market as indicated in Table 1.

Varieties

Traditionally only oat varieties with a tall genotype have been accepted for use in the milling market in Western Australia because the grain meets both the physical and chemical attributes desired by industry. Mortlock and Carrolup are varieties that have been bred and released for use by the milling market.

Varieties containing dwarfing genes have generally not produced grain that has been acceptable to the milling industry. So in the past all varieties with a dwarf genotype have only been accepted for use in the feed industry. Dalyup and Wandering(b are varieties that have been released for use by the feed industry.

Table 2 compares some of the physical and chemical attributes of Mortlock, Carrolup, Dalyup and Wandering(b grain (Figure 1). Mortlock and Carrolup have a high hectolitre weight, high groat percentage and a high milling yield. Dalyup is not suitable for the milling market as its ease of dehulling is poor and its milling yield is low. Wandering(b seems to have suitable attributes to be classified as a milling variety, however when it was released the milling industry did not accept it due to the poor taste of the processed oats.

The benefits that varieties with dwarfing genes offers growers in terms of higher grain yields, less lodging and less head loss have now become available with grain quality suited to the milling market. This removes the market distinction between oat varieties based on their height genes. The National Oat Breeding Program has recently released two dwarf oat varieties Mitika(b and Possum(b which have been accepted for use in the milling industry in South Australia. In March 2007 the status of the dwarf oat Kojonup(b was upgraded to milling. Kojonup(b is the first dwarf oat variety to receive a milling classification in Western Australia. It has higher milling yields, higher goat percent and higher soluble fibre levels than the dominant milling oat variety Carrolup. Commercial milling trials to determine the suitability of varieties for use in the milling industry are undertaken under the guidance of the peak oat industry body in Western Australia, the Western Oat Alliance.

Some oat varieties also have potential for use by both the milling and animal feed markets. Many growers retain grain on farm to use as animal feed so achieving a premium quality grain with the added benefit of high feed value (and of course high yield and disease resistance) is desirable. The attribute for each type of oat in Table 1 suggests that this is not always likely to be the case.

Milling varieties have not traditionally been bred for optimum digestibility and metabolisable energy so most current tall milling varieties (i.e. Carrolup and Mortlock) do not make ideal feed varieties. Varieties are now being evaluated and released by the National Oat Breeding Program that combine traits suitable for the milling industry combined with high grain digestibility and metabolisable energy (i.e. Kojonup(b and Mitika(b). As a consequence varieties suited to both the feed and milling industry will become more readily available to growers.

For more information on oat varieties suited to growing in Western Australia refer to the Oat Variety Guide for WA, variety information brochures and the Department of Agriculture and Food website (www.agric.wa.gov.au) and search for Oat Production in Western Australia.

Specifications for delivering oats

Not all oat grain grown in Western Australia is delivered to a grain trader. The largest grain trader or purchaser of oat grain in Western Australia is the CBH Group through their subsidiary AgraCorp. All oat grain delivered to AgraCorp is currently tested for moisture percentage, hectolitre weight, screenings and admixture, based on standards set by CBH in consultation with the oat industry. Oat grain is not currently tested for grain protein percentage, however this may change in the future. For oat grain to be received into the premium grade – OAT1 – it must be of a certain variety, have a minimum hectolitre weight of 51 kg/hl and a maximum screenings through a 2 mm slotted sieve of 10%. For oat grain to be received as OAT2 it must have a minimum hectolitre weight of 49 kg/hl. There is no limit on screenings for oat grain delivered as OAT2. Variety specific segregations may also exist on a seasonal basis that are set up to meet niche markets requirements. The variety Wandering(b is one such variety for which a variety specific segregation has existed. It should be noted that receival standards may change from season to season. In seasons with a dry finish and low expected supply, there may be some relaxing of the limits for hectolitre weight and screenings to ensure market demand can be met.

The nutritional value of oats has always been known but has particularly been taken advantage of over the past 20 years. Oats have a variety of attributes which make them a valuable component of many foods, particularly their antioxidant effects. As studies continue to correlate the improvement in health (such as reduction in cholesterol levels) to the consumption of oats (oat bran), the number of products containing oats or oat products have increased, particularly in recent years.

***Figure 2**. End products made using oats.*

Products produced in the oat mill include rolled oats, steel cut groats, different sized flakes from the cut groats (for cereals or porridge), oat flour and oat bran. Oat products are now incorporated into a wide range of foods including breakfast cereals, porridge, muesli, cereal bars, bread and oat milk (Figure 2).

The milling process

The prime objective of the milling process is to remove the husks to obtain maximum groats (milling yield) and produce a final product with maximum taste, appearance and shelf life.

The end market of milling oats has strict tolerance levels of foreign material such as husks and skins as well as foreign seeds (barley and radish) and other contaminants. The end product is tested by customers and can be rejected. Millers now have a strict screening process at every step of the milling process with regular sampling points for enhanced quality control.

There are four main steps in the milling process: Step 1 is cleaning and grading, Step 2 is dehulling and groat separation, Step 3 is steaming and kilning and Step 4 is the final processing. The particular mill and end product will determine whether the groats are kilned and when steaming occurs in the process. Figure 3 shows a flow diagram of a typical milling process.

STEP 1 – Cleaning and grading

Raw material (harvested oats, Figure 4) has foreign grains, free groats (oat kernels), small oat grains and foreign objects. The cleaning and grading step aims to remove foreign material and grade the grain to a uniform size. The cleaning and grading process continues throughout each step of the milling process.

STEP 2 – Dehulling and separation

The aim of the dehulling and separation step is to remove the hulls leaving unbroken groats (dehulled oat grains, Figure 4). The cleaned and graded oats are dehulled using high speed rotors that throw the oats against a hard surface. The hulls are detached by impact and abrasion. The speed of the rotors is adjusted to ensure enough force is used to dehull the oats, yet gentle enough to minimise groat breakage. The milling yield of oats refers to the proportion of unbroken groats produced from a given amount of raw material.

Figure 3. *Flow diagram of a typical milling process.*

***Figure 4**. Harvested oats (left) before being cleaned, graded, dehulled and separated into dehulled oats or groats (right).*

STEP 3 – Steaming and kilning

The aim of this step is to stabilise the groats. The unbroken groats are subjected to steam treatment to deactivate enzymes that would otherwise produce rancidity from the oil content during storage. The groats may also be kilned (baked) to develop the full oatmeal flavour.

STEP 4 – Final processing

The stabilised groats are then further processed for the consumer. The end product to be produced determines the level of processing required (Figure 5). For rolled oats the whole groats are softened with steam and then rolled into flakes. For quick or instant rolled oats the whole groats are cut into two to three pieces and then rolled into thin flakes. When making oat bran or flour the groats are milled to produce wholemeal flour. The coarser fractions of the flour can be separated out as fibre rich bran. Kilned groats and cut groats are other products also available and they are steamed to soften prior to rolling.

Impact of grain quality on the milling process

Table 3 looks at the impact that some of the grain quality attributes can have on the way in which the oat grain processes during the milling process and how the different attributes might influence the quality of the final product. Other varietal considerations for mills are how well the grain rolls and how well the variety absorbs water. All of these factors are determined prior to the release of a new variety.

Figure 5. *End products from the milling process include from (left to right) top - rolled oats, instant oats and oat bran and bottom – oatmeal (flour), kilned groats and cut groats.*

Table 3. Importance of different quality traits to processing of oat grain during the milling process.

Step and grain quality trait	Importance
	STEP 1 – Cleaning and grading
Screenings	Screenings are the amount of small grain passing through a 2mm screen. Millers prefer larger sized grains of uniform size to assist with setting up rollers and maximising milling yield.
% Free groats	Percent free groats is the number of free groats produced during harvest of a given sample. Millers prefer a sample with a limited number of free groats as they tend to have mechanical injury and are more likely to become rancid.
	STEP 2 – Dehulling and separation
Hectolitre weight	Measures the density of the raw oat material.
Groat %	Groat % represents the economic yield from a sample of oat. A higher groat percent means a lower proportion of low value husk and a high milling yield.
Ease of dehulling	Refers to the amount of force needed to dehull a given sample of oats. The greater the force needed to dehull, the greater number of broken groats and the lower the milling yield.
Groat hardness	A harder groat means less breakage during dehulling and leads to a higher milling yield.
	STEP 3 – Steaming and kilning
Moisture	Moisture impacts on the kilning and steaming process. While moisture decreases during the kilning process, it actually increases again during the steaming process, thus impacting on the storage potential of the groats. So a load delivered at 13% moisture will reduce to 11% in the groats after kilning but increases to 14% after steaming which will reduce the time groats can be stored and consequently the shelf life of the final product. Complications can occur when shandied loads (different moisture content) are delivered. The higher content will remain throughout the milling process and will ultimately reduce the shelf life of the final product.
	STEP 4 – Final processing
Grain protein %	A high protein content in oats is desirable for human consumption.
Oil %	Oil in oats naturally binds with starch and can influence the behaviour of starch during cooking. This then affects the final texture of the product. Oats is the only cereal to contain significant quantities of oil (4 - 8%). Oil content can limit the storage time of raw groats as the oil will degrade and go rancid over time. Low oil content is desirable for human consumption.
Beta glucan %	Beta glucan is a water soluble polymer that has been shown to reduce the uptake of fats and sugars during digestion and lower blood cholesterol levels. Oats contain between 3 to 7% beta glucan. Higher levels of beta glucan are desirable for human consumption.
Grain plumpness	Groat weight or grain plumpness is an indication of the how much of the sample has larger sized groats with uniform seed size preferred by millers to produce rolled oats.
Groat colour	Groat colour is important particularly for the end consumer who prefers bright flakes of oats and a white, creamy porridge.
Starch quality	Starch quality helps determine the suitability of oats for cooking and further processing. Consumers prefer porridge to have a creamy texture (good mouth feel or viscous) which is determined by the starch quality of the variety.
Taste	Taste is vital for oats milled for porridge. Consumers seek a 'nutty' taste opposed to a 'sour' taste which has been the case with some varieties. Taste panels are used in the evaluation of new varieties seeking a milling classification to determine taste and mouth feel. Taste is not as important for oats milled for muesli bars and other products that have sugars and other ingredient added to enhance the flavour.

Oats for animal consumption

Oats is the most common grain fed on farm as a supplementary feed due to the lower cost of production. Oats generally have a lower energy level than other cereals and, with a higher fibre content, are considered safer to feed than wheat or barley as they are slower to digest and pose less chance of grain poisoning.

Figure 6. *Western Australian oats are widely recognised by the international racehorse market including the Middle East and Japan*

There are three main markets for Western Australian feed oats:

1. International markets: Overseas markets have recognised the benefits of feeding oats, particularly Western Australian oats which have a bright and plump grain and are low in admixture. This market is a major growth market for our oats which is now recognised world wide for quality and safety. The horse racing market is one of the main feed markets we service overseas (Figure 6).

These markets are beginning to understand the additional feed value of these oats, however their preference is currently for varieties with plump, bright grains such as Wandering(b, Dalyup and Euro.

Oats can be value added prior to export by being clipped and dressed and packaged (Figure 7). Western Australian oats present very well due to their brightness and plumpness.

2. Processed feed: Oats and even oat husks are also used in processed animal feed including pellets. Quality other than required receival standards is currently considered not as important as yield for this market.

3. Domestic/on-farm feed: In recent years growers have recognised that oats are not just oats and that some varieties have significantly better feed value than others. Feed lots now demand oats with high nutritional value and good appearance (bright, unblemished grain). There is also an increasing awareness of varieties with a low hull lignin.

Feed quality parameters

The National Oat Breeding Program is selecting feed varieties for improved feed value, indicated by such quality traits as metabolisable energy, digestibility, lignin content, protein concentration, oil concentration and groat percent. Colour and brightness is an important component for overseas markets that are looking for a bright 'clean' grain free from toxins and mould.

The main nutrients that limit animal growth are protein and energy. Both nutrients are important for healthy rumen function and conversion of feed into meat products.

Metabolisable Energy (ME, MJ/kg DM) is the net energy available to an animal after energy is spent in the digestion and absorption process and loss of some material as being undigested or indigestible. ME is a predicted value which is correlated to the oil content of the grain. The high ME content of oil means that a small increase in oil content can increase the feeding value of oats significantly.

Grain protein is a large organic compound made of chains of amino acids. Protein forms an essential part of body mass, particularly in growing animals, which is maintained by including protein in the diet. Protein percent in oats is dependent on the variety, season and management. In most years the protein percentage of oats is low and will need to be

Figure 7. *Oats for export feed is processed (clipped and dressed) and packaged for maximum presentation as can be seen from the sample of Euro.*

supplemented with lupins to provide adequate nutrition for lactating ewes. It is worth testing your oats to determine protein levels as it may result in savings should levels be adequate.

Digestibility is a measure of the diet which can be digested. Digestibility is normally measured as **Digestible Dry Matter** (DDM) which is the difference between the dry matter consumed and that excreted in faeces expressed as a percent of the dry matter consumed. DDM is generally measured by an *in vitro* laboratory procedure (**In Vitro Digestibility – IVD)** calibrated against feedstuffs of known DDM values determined from feeding trials with live animals, usually sheep.

Hull lignin is an indigestible carbohydrate in the hull which influences the feeding value of oats. A lot of emphasis has recently been placed on lignin for feed oats but it is important to note that it is one of many factors when comparing feed quality parameters (groat percent, protein, ME etc). Low lignin varieties have traditionally had a darker grain. The National Oat Breeding Program now has an emphasis on breeding low lignin varieties with a lighter coloured grain. Metabolisable energy of oats can vary 1.5 MJ/kg ME between high and low lignin varieties.

Acid Detergent Fibre (ADF) measures the indigestible fibre in the plant and is made up of cellulose and lignin. Fibre is essential for good rumen function and health. Animals are able to digest hemicellulose and assessable components of the cellulose, but not lignin.

Proportion of hull (correlating to the **groat per cent**) is an important factor for feed quality. Generally the hull is indigestible and has a high amount of fibre, thus having a negative effect on feeding value. The digestibility of the hull increases as the hull lignin content decreases. Protein and energy comes from the groat. Therefore the higher the groat percent the more chance the animal has of maximising nutrient intake.

Colour and brightness is particularly important for the export markets who do not want stained or blemished oats. These markets are yet to accept darker coloured oats (i.e. low lignin varieties) for feed, even though they may have superior feed quality. It is expected that this may change over time.

Oil and beta glucan: As oil concentration correlates with ME, a higher oil concentration is desirable for feed oats, as opposed to a lower concentration for milling oats. While a high beta glucan is desirable for milling oats, animal feed requires a low beta glucan.

Feed value of oats

Oats is the most common grain used as a supplementary feed on farm for ruminant livestock in Western Australia. This is because oats have a high production potential and require relatively low management compared to other crops. It is important to note that the highest quality oat crop will be achieved on the best paddocks.

The main nutrients that limit growth are energy and protein. Both nutrients are required for healthy rumen function and the efficient conversion of feed into meat products. While oats are comparatively easier to grow than other crops, consideration also needs to be made for the nutritional requirements of livestock and whether other supplementary feeds may need to be added to the diet. Table 4 illustrates the range of nutritional values of different grain based sheep feeds.

It is important to have feeds tested for energy and protein percent so you can be sure the sheep are receiving the correct amount of energy and protein for maintenance or growth as well as to provide them with the most cost

Table 4. Grain based sheep feeds: the dry matter, energy, protein and fibre contents (dry matter basis). Range of values with the average shown in brackets.

Feed grains	Dry matter (%)	Metabolisable energy (MJ/kg)	Crude protein (%)	Acid detergent fibre (%)
Cereals and Pulses				
Oats	92	10.4 – 11.3 (10.7)	5.5 – 13.5 (9.0)	16.0 – 21.5 (18.5)
Wheat	91	12.4 – 13.3 (12.9)	7.5 -15.0 (11.5)	2.5 – 4.5 (3.0)
Barley	91	11.6 – 12.2 (11.9)	7.0 – 13.0 (11.0)	7.0 – 9.5 (8.0)
Triticale	90	12.0 – 13.0 (12.5)	7.5 – 14.0 (11.0)	3.5 – 5.0 (4.0)
Narrow Leaf Lupins	92	13.1 – 14.1 (13.7)	27.0 – 42.0 (34.0)	17.5 – 23.0 (20.0)
Peas	91	12.5 – 13.5 (13.0)	21.5 – 30.0 (25.5)	6.0 – 10.5 (9.0)
Vetch	91	12.4 – 13.2 (12.8)	26.0 -34.5 (29.0)	7.5 – 9.5 (8.5)
Cereal Seconds				
Wheat	92	11.8 – 12.4 (12.1)	12.5 – 17.0 (13.5)	3.5 – 5.5 (4.5)
Barley	93	11.1 – 11.8 (11.4)	11.0 – 14.5 (12.5)	9.5 – 12.5 (10.0)
Triticale	92	11.3 – 12.1 (11.7)	10.5 – 15.5 (13.0)	4.5 – 6.5 (5.5)
Oats	93	9.8 – 10.5 (10.3)	4.5 – 16.0 (12.5)	21.0 – 26.0 (23.5)
Sheep Pellets				
Maintenance	90	8.0 – 9.0 (8.5)	8.5 – 9.5 (9.0)	29.5 – 32.0 (31.0)
Production	91	10.6 – 11.4 (11.0)	13.5 – 16.0 (15.0)	20.0 – 25.0 (23.0)

These values were extracted from data collected by Independent Lab Services, Perth and presented in the Good Food Guide for Sheep (DAFWA 2002).

effective diet. Samples can be tested by an accredited laboratory such as Independent Lab Services in Western Australia (08 9242 5876) or FeedTest Australia in Victoria (1300 655 474).

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Further Reading

Bulletin 4473: The Good Food Guide for Sheep (DAFWA 2001)

Farmnote 65/91. Selection of Supplementary Feeds

Farmnote 209/06. Oat Hay Quality for Export and Domestic Markets

Oat Variety Guide for WA (DAFWA Farmnote released annually) available at: www.agric.wa.gov.au ➞ Crops ➞ Oats

Oat Production in Western Australia (web pages) available at: www.agric.wa.gov.au ➞ Crops ➞ Oats

Zwer P. and Faulkner M. (2006). Producing Quality Oat Hay (RIRDC Publication 06/002) ISSN 1440-6845. Also available at www.rirdc.gov.au/fullreports/fodder.html

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