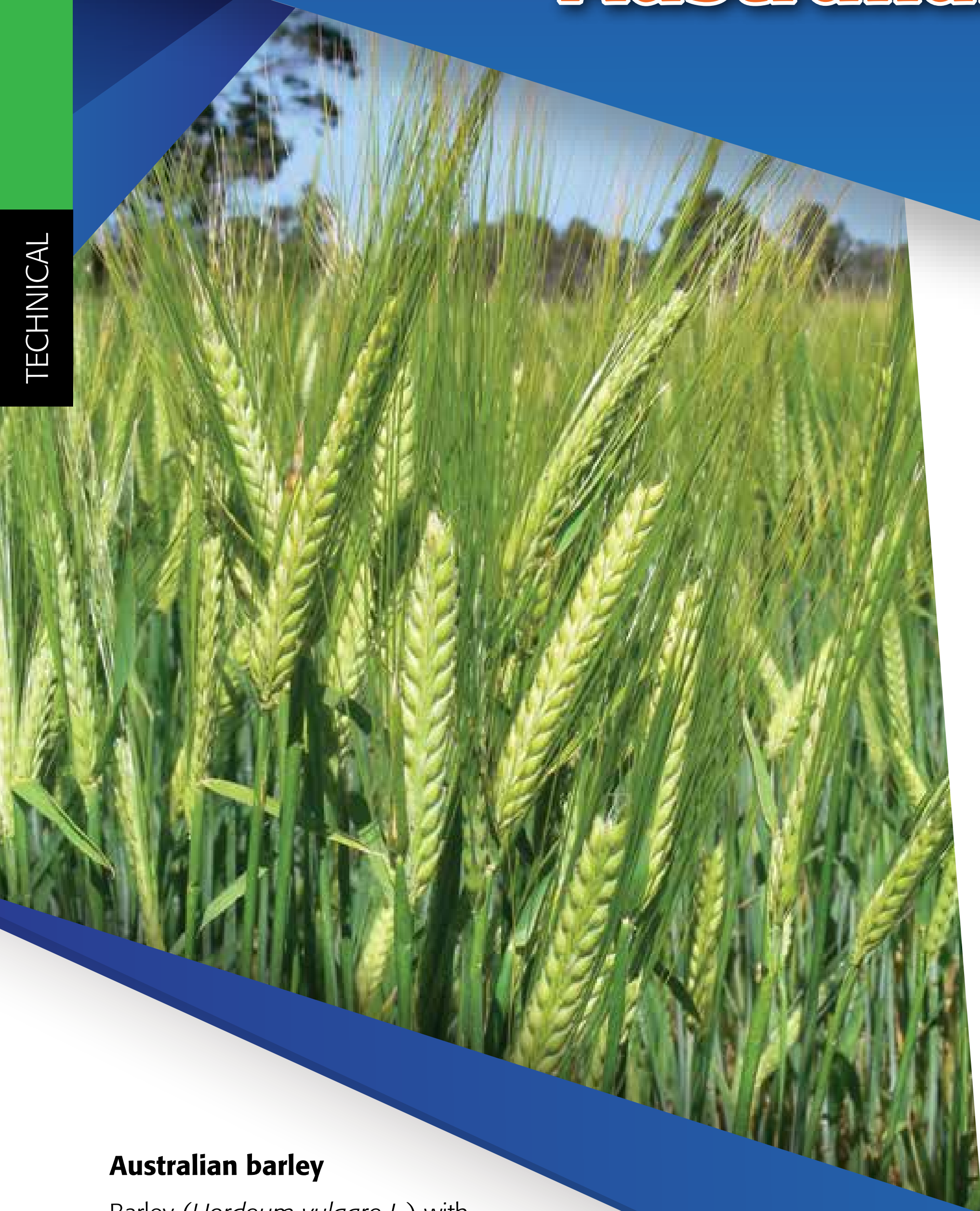
Australian barley for pigs



Dr BRENTON HOSKING* explains that barley contains less digestible energy than corn and wheat, because of its higher concentration of crude fibre, which can be an advantage or disadvantage, depending on how you use it. It is suitable for all types of pigs and provides more amino acids and more phosphorus than corn.

Australian barley

Barley (*Hordeum vulgare L.*) with global production of 142 million tonnes in 2017-18, was the fourth most widely grown grain after corn, wheat and rice. Australian barley is predominantly of the two-row type and while grown primarily for the malting market, on average 70% of the Australian barley crop is used for animal feeding, either in domestic or export markets. Varieties have been bred for their agronomic characteristics including yield and disease resistance. Six row and specific feed-type barleys with higher protein content are grown but not in the same quantities.

Factors affecting the use of barley in pig feeds

The predominant influences on the use of barley grain in pig feeds are its composition, its flexibility in use across all stages of pig production and its processing characteristics.

Composition & formulation

The potential for barley as a feed grain in pigs and poultry, is influenced by its high fibre (non-starch polysaccharide, NSP) content and low energy density relative to corn and wheat. These are often regarded as significant anti-nutritional factors. Barley does have a relatively high β-glucan content and a higher content of soluble NSP which can lead to some disruption to digestion and

This paper was presented at the

pig QC
FEED QUALITY CONFERENCE
Bangkok, Thailand 26-27 April 2018

subsequent productivity in both meat and layer birds – but in pigs it's not usually an issue. Pigs have a larger gut volume and longer retention times for material at each phase of digestion than chickens enabling them to better cope with the effects of NSP present in barley.

Compositional information (Table 1) indicates the higher fibre content and lower starch and digestible energy (DE) content of barley relative to corn and wheat. Differences are also evident in the mineral content of the respective grains, with barley capable of yielding more dietary phosphorus than corn in formulation. If compared at an equivalent protein content (Table 2), barley shows higher lysine and tryptophan values than corn, although the concentrations of methionine, threonine, isoleucine and leucine are lower than corn. In practice, barley generally has a protein content at least two units higher than corn and then contributes more of every standardised ileal digestibility (SID) essential amino acid except for methionine (and leucine) than corn.

Fibre, is that fraction of the feedstuff that includes non-starch polysaccharides (NSP) and polyphenolic compounds (lignin). Lignin is effectively insoluble and unavailable to the animal. The NSP component consists of soluble and insoluble components. In the case of barley and to a lesser extent wheat, it is the soluble NSP component that may impair digestive function. The highly branched structure of soluble NSP arises from high concentrations of pentosans and other non-hexose sugars that affect how these compounds hydrate and interact with the gut environment to increase digesta viscosity.

Insoluble NSP generally provide a physical barrier to access by digestive enzymes and by their nature are poorly hydrated during processing or digestion. There is increasing evidence that while nutritionally inert they can be beneficial for gut development and function and animal welfare. Where NSP are suspected to limit performance a range of carbohydrases and enzyme complexes, are readily available. Enzyme products that deliver multiple activities can overcome the deleterious effects of NSP and

Table 1: Proximate analysis (%) and selected mineral content of barley, corn and wheat grains.

	Barley	Corn	Wheat
Crude protein	10.1	8.2	12.7
Crude fat	1.8	3.7	2.4
Crude fibre	4.6	2.2	1.5
Neutral detergent fibre	18.7	10.4	9.8
Acid detergent fibre	5.5	2.6	2.2
Acid detergent lignin	1.0	0.5	0.4
Starch	52.2	64.1	59.6
Digestible energy (MJ/kg)	12.8	14.5	14.3
Calcium	0.07	0.04	0.09
Digestible P	0.13	0.04	0.17
Phytate-P[a]	0.196	0.186	0.219

adapted from DAF Queensland, 2018; [a] adapted from Selle *et al*., 2003

Table 2: Selected amino acids in barley, corn and wheat grains shown as % grain and % protein.

	as % grain			as % protein		
	Barley	Corn	Wheat	Barley	Corn	Wheat
Crude protein	9.0	9.0	9.0	100	100	100
Lysine	0.29	0.25	0.24	3.2	2.8	2.7
Methionine	0.14	0.18	0.14	1.6	2.0	1.6
Threonine	0.23	0.28	0.23	2.6	3.1	2.6
Tryptophan	0.08	0.06	0.11	0.9	0.7	1.2
Isoleucine	0.26	0.30	0.28	2.9	3.3	3.1
Leucine	0.51	1.03	0.55	5.7	11.4	6.1

adapted from Walker, 2017

Table 3. Typical fibre content (% of grain, DM) of barley, corn and wheat

Type	Barley	Corn	Wheat
Soluble	4.5	0.1	2.4
Insoluble	15.4	9.0	10.8
Total	19.9	9.1	13.2

adapted from Choct *et al*.,2010

Table 4: Physical characteristics of barley, corn and wheat.

Type	Barley	Corn	Wheat
Moisture %	10.3	11.1	10..3
Thousand grain weight g	45	380	50
Test weight g/hL	65	81	78
Screenings %	3.2	1.9	1.8

Source: Tasmanian stockfeed services intake summary 2017

Table 5: Re-grinding hammer-milled barley grain to eliminate particles >1mm improves FCR.

Form	Mash	Pellet	Mash	Pellet
Grind	Milled	Milled	Reground	Reground
Dgw (Sgw)	1.06 (0.77)	1.06 (0.74)	0.76 (0.41)	0.77 (0.43)
Grower pigs intake kg / day	1.62	1.66	1.60	1.63
Daily gain kg	0.80	0.84	0.86	0.85
Feed:Gain ratio	2.04[a]	1.96[b]	1.88[b]	1.90[b]

adapted from Sopade *et al*., 2013

promote the availability of amino acids, phosphorus and other minerals,

Flexibility in use and application

As barley is similar in size and shape to wheat (Table 4), little adjustment is required to grain handling and milling procedures to enable its use in a wide range of animal feeds. Provided adjustments are made for its nutritional content and test weight, it can be used in all forms of pig feed, including rations for starter pigs, grower pigs and in both lactating sows and breeders.

The flexibility of Australian barley as a feed ingredient comes in part from the reliability of the grain production and trading environment. Australian grains are traded across the grain production, accumulation and trading sectors according to nationally recognised grain trading standards. These standards create a common language for producers, marketers and consumers to identify the likely quality characteristics and risk profiles for individual grades of grain. In practice, this provides an integrated and transparent system by which end-users can gauge the likely performance characteristics of the grain when selecting a grain-type. For example, Australian barley is generally low in moisture content and grown and harvested under conditions that minimise the risk of mycotoxin contamination. While the grain trading standards do not specify limits to mycotoxin content, they do include indicators such as discolouration, fungal inclusion & staining – all of which are indicative of the potential for the presence of mycotoxin. Selection for grain quality against a reliable grain standard is a common risk management strategy for Australian feed mills.

Consistent formulation – consistent outcomes

There are at least four stages between the formulation and feeding of commercial - the ration as formulated; the ration that is manufactured, the ration as fed and finally, what is consumed. The last ration is important to the animal. The first ration requires accurate information on the composition of the ingredients used. The formulation strategies used by swine nutritionists commonly involve multiple diets across the life of the animal with formulations adjusted according to season (summer & winter formulations), stage of growth (weaner, grower, finisher), sex (male, female and castrate rations), and for whether the sows are group housed.

Rations are formulated to digestible energy (DE) and SID amino acid specifications based on the nutrient requirements of the animal rather than set ingredients and maybe adjusted monthly or even more frequently if there is some change in raw material use.

This approach recognises that (a) at the tissue level, animals require nutrients not ingredients and (b) that all ingredients/raw materials will be subject to some degree of variation in nutrient content according to source, processing method or other environmental factor. Most commercial feed manufacturers operate NIR-based quality assessments of incoming raw materials to ensure ingredients match the desired formulation and mill production requirements as closely as possible.

Barley is commonly used in conjunction with other grains to stabilise the ration formulation. Using more than one grain provides additional flexibility should rations need to be changed to suit raw material availability or animal or customer demands. There are three main reasons for doing this. The first is that pigs can be wary of new tastes and feed ingredients. It is easier to introduce changes in grain inclusion in the diet if the animals have been exposed to the grain previously. The second is that abrupt changes in ration composition can lead to digestive upset. It is less disruptive to gut function and overall performance if adjustments to the ration are made in stages (10-15% changes in grain inclusion) rather than as abrupt shifts in grain inclusion. Pigs develop diet specific microbiota according to the degree of gut development, health status and ration-type. The third reason is that the Australian consumer has come to prefer lean pork of a particular colour and eating quality. Producers are penalised at sale if stock provided for slaughter do not meet rigid specifications for leanness (P2 fat depth) and other meat quality characteristics. Barley grain is an ideal inclusion to manage the energy density of grower and finisher feeds to achieve desired market requirements. Barley grain is also an ideal choice for managing the fibre content of both breeder and lactating sow feeds to maximise gut health and productivity.

Barley is readily milled through conventional milling equipment and it is usually fed pelleted, rolled or tempered (soaked). It is often included at 5-10% as whole grain in sow diets to aid gut health and prevent constipation. Its gelatinisation temperature (50-60°C) is similar to that of wheat and generally below that of corn (>65°C). Barley is not usually fed in hammered form as it can become dusty with the potential for issues in handling, feed segregation and palatability.

Particle size and particle size distribution during feed preparation has been shown in studies supported by the Australian Pork CRC to have significant effects on feed efficiency for both hammer milled and disc milled grains. It has been established that barley particles >1mm in size are digested one hundred times more slowly than smaller particles. Subsequent surveys of commercial feed mills and home mixers revealed a wide range in grain particle sizes with many samples showing average particle sizes well above the suggested optimum of 700 micron. Removing the larger particles by screening and re-grinding hammer-milled barley to produce a more uniform particle size distribution resulted in a reduction in feed:gain ratio of more than 7% (Table 5). Commercial studies undertaken with more than 3,000 pigs fed pelleted, disc-milled barley-based diets found that reducing the grind size from 1,100 to 600 micron had no effect on average daily gain, but reduced feed intake. This resulted in a 2.6% improvement in feed conversion ratio (FCR) in the grower phase and 5.6% improvement in the finisher phase. There is significant potential to improve feed efficiency and lower the cost of production of barley-based feeds by adjusting milling equipment closer to optimal particle size. As calculated by Edwards, a 5% reduction in FCR represented a saving of 8.5 kg of feed/pig.

Cost and availability

The price of barley for animal feeds varies according to a multitude of factors including overall production and domestic consumption, its price relative to other feed grains including wheat and sorghum, the operation of the Chicago Board of Trade futures markets, world malt prices and other seasonal factors affecting its quality and availability. Prices vary according to quality characteristics by region of production and within and between seasons. When barley trades below the price of wheat, its inclusion in animal feeds increases. AF

**Dr Brenton Hosking (brentonhosking@gmail.com), is Technical Director, AMJ Feed Services, Australia. References are available on request to the author.*