FROM WHEAT TO MEAT

The first in a series of articles in which Dr Gary Partridge, of Finnfeeds International discusses the nutritional value of raw materials

As the Finnfeeds Technical Services Manager for Porzyme, Dr Partridge provides specialist advice to the animal feed trade on various aspects of pig nutrition – particularly the use of in feed enzyme systems.

Before his appointment by Finnfeeds he worked for five years as the Nutritional Pig Advisor with BP Nutrition (UK) - now Trouw Nutrition (UK) Ltd. Prior to this he was a Senior Researcher at the Rowett Research Institute in Aberdeen, Scotland specialising in young pig nutrition. He regularly publishes articles for the animal feed trade and farming press and has published many papers in scientific literature.

Wheat is a major energy and protein source for non-ruminant feeds on a world-wide basis. For instance, about a fifth of the global annual wheat crop is used in animal feeds with Europe, including Russia and the republics of the former Soviet Union, accounting for nearly two-thirds of the 115 million tonne total livestock wheat intake.

Statistics sourced from Trouw Iberica, Spain, suggest that in 1994-95 in the European Union (12 countries) total animal consumption of cereals was about 142 million tonnes. Of this 23.5 million tonnes were wheat, 30 million tonnes barley, 22.5 million tonnes maize and a further 8 million tonnes of other cereals.

Little wheat finds its way into animal feeds in Asia, Africa or Latin America. Even in the United States, wheat use is relatively low - 8 million tonnes in 1994 - about a tenth of the annual crop. While the advent of higher-yielding varieties means that wheat can be grown successfully between the latitudes of 30 degrees and 60 degrees north and 27 degrees and 40 degrees south, factors such as price, world trade politics, climate, storage facilities, and competing crops all influence its popularity in specific countries. Even so, a wheat crop is being harvested somewhere in the world in every month of the year.

Unfortunately, harnessing the potential from newer varieties comes at a cost - often needing higher nitrogen rates and water use to succeed - which makes wheat expansion more likely in the prime growing areas of the world. Also,

The Microstructure of wheat

right: Figure 1, below: Figure 2

Seed coat ➡

Auleurone layer ➡

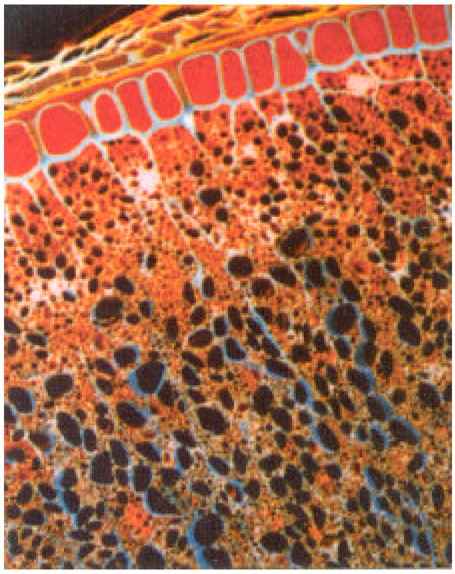
Subaleurone layer ➡

Cell wall (blue) ➡

Starch (black) ➡

Protein (red, brown) ➡

Starchy endosperm ➡



Cross section of whole wheat grain

developments in rice cultivars continue to maintain its edge over wheat and other cereals throughout Asia.

Pigs and poultry are the main consumers of wheat and wheat by-products. A world-wide assessment by Finnfeeds International reveals that countries with relatively high wheat use in livestock diets may average between 40-50 per cent inclusion rates in pig diets and up to 100 per cent of the cereal component in poultry rations.

In the UK, wheat and its by-products comprise 41 per cent of compound pig feeds for finishers, according to Ministry of Agriculture 1995 annual statistics. Inclusion rates rise to 44 per cent in rearing compound feeds and up to 51 per cent in sow rations. UK poultry compound feeds average between 44 and 48 per cent wheat inclusion for layer, broiler starter and finisher compounds **(see Table 1.)**

A 1994 analysis of the pig feed market by Finnfeeds suggested that wheat based pig feed is predominant in Germany and France. In Germany nearly 40 per cent of pig feed was wheat-based (double the barley-based segment) and in France over 30 per cent of pig feed was wheat-based, compared to a barley-based pig feed segment of under 5 per cent. By contrast, over 80 per cent of the Dutch feed in 1994 was predominantly based on other raw materials (such as manioc), while Spain has traditionally used barley-based feed.

With more than 150 million tonnes of compound pig feed produced globally each year - plus the millions of tonnes used in home mixes - a third of this feed world-wide is based on the viscous cereals (wheat, barley, oats, rye and triticale) with wheat the predominant cereal used in many countries.

Wheat contains, as a percentage of dry matter, about 70-80 per cent carbohydrates, 8-18 per cent proteins and 1.5-2.5 per cent lipids.

However, the composition of modern varieties can vary widely - starch levels can fluctuate between 600 and 730g/kg dry matter. Similarly, crude protein content ranges from 80 to 140g/kg with a more recent study showing a variance between 96 and 170g/kg **(see Table 2.)**

Figures 1 and 2 show the structure of the whole wheat grain and a cross section through the various layers. The seed coat or bran layer constitutes the bulk of the grain's crude fibre content. It comprises lignin and fibre polysaccharides. The pericarp is a layer of cellulose impregnated with minerals and forms the tough outer layer of the seed coat. The inner layer is formed from the testa, which is made up of small, brown pigmented cells that contain some cellulose.

Starch comprises 64-74 per cent of the endosperm and provides the energy component of the wheat-based diet. This starch is contained inside cell walls as distinct granules and is formed from two polysaccharide components, amylose and amylopectin. The difference between wheat varieties in grain filling, starch development and cell wall structure within the endosperm dictate the availability of starch for digestion.

The other important group of carbohydrates present in wheat are the fibre polysaccharides which form about 10 per cent of the whole grain and are mainly found in the bran layer. This group comprises mainly mixed-linked ß-glucans, arabinoxylans and cellulose.

The anti-nutritive effects of fibre have been well-documented in broiler research. Soluble ß-glucans and, to a lesser extent, soluble arabinoxylans can cause stickiness (viscosity) within the digestive tract leading to the 'sticky droppings' condition classically found in poultry when offered barley-based rations.

In the pig this viscosity effect, although less marked, remains important and is thought to partly explain why wheat is often implicated in

	Total cereals (wheat)	Cereal by-products	Animal/vegetable proteins	Others
Sows	20(15)	46	25	10
Pig rearing	49(33)	12	33	6
Pig finisher/fattening	42(34)	14	39	6
Broiler starter	55(44)	2	37	6
Broiler finisher	59(48)	1	34	5
Poultry layer	46(44)	15	27	12

Table 1

UK Pig and Poultry compound composition per cent 1995

	Ave (g/kg DM)	Range
Starch	675	600 - 730
Crude Protein	128	96 - 170
Total fibre*	126	89 - 180
Free sugars	31	16 - 54
Crude fat	24	19 - 30
Ash	16	11 - 19

*arabinoxylan, cellulose, ß-glucan and lignin

Table 2

Wheat composition range in 115 Swedish wheats over 4 years (Graham et al 1988)

Country	Ave energy (MJ/kg DM)	Range	Highest –lowest value (MJ)	Sample nos	Reference
Canada	15.8	15.0 – 16.4	1.4	7	Bowland 1974
Australia	16.2	15.7 – 16.9	1.2	8	Batterham et at 1980
UK	16.1	15.1 – 16.4	1.3	8	Wiseman & Cole 1980
Canada	16.3	15.5 – 17.0	1.5	15	de Lange et al 1993
UK	15.4	14.4 – 16.0	1.6	32	Wiseman et al 1994

Table 3

How wheat energy levels vary – grower/finisher pig trials

	Control	Control + Porzyme
Start weight (kg)	8.2	8.0
Finish weight (kg)	20.2	23.3
Daily gain (g)	304	385
Daily feed intake (g)	512	572
FCR	1.69	1.49
Days on trial	40	40

Table 4

Results of low-cost wheat/soya diet with Porzyme supplementation

colitis - a non-specific scour disorder predominantly found in young pigs - resulting in the passing of loose faeces and affecting growth rate and food conversion efficiency. However, while high wheat levels and pelleting are associated with this disorder, it may also be exacerbated by other raw materials such as soya bean meal.

Although wheat is an attractive raw material for pig formulations in many countries, this is one of the negative characteristics which have tended to restrict its use at high levels in pig diets. Increased incidence of gastric ulceration has long been another major concern with feeding high levels of wheat in pig rations although recent Danish work has shown the positive effects of efficient rolling techniques, compared to fine grinding of the grain.

Wheat and wheat by-products also contain insoluble fibres - especially arabinoxylans. Both soluble and insoluble fibres have a sponge-like capacity to bind water and this, together with the viscosity of the soluble fibres, is known to slow digesta transit and potentially encourage microbial proliferation in the small intestine. This leads to competition between the animal and microbes for nutrients and can predispose the animal to digestive upsets.

The presence of these anti-nutritive factors in wheat also may lead to excessive and thereby inefficient endogenous enzyme production. This is a ‘cost’ to the animal, diverting energy and amino acids away from productive processes e.g. growth.

The cell walls of wheat - particularly in the aleurone layer which is rich in minerals and protein - can remain largely intact both after processing and chewing in the mouth of the animal.

Certain xylanase activities can increase the permeability of these cell walls, allowing better access for the animal's own endogenous enzymes. The net effect is an improvement in nutrient digestibility.

Within the poultry sector, enzyme supplementation is now common place and has had a dramatic effect on reducing variability in feeding value of wheat by specifically targeting the key anti-nutritional factors.

Figure 3 shows how enzyme use can not only improve AME value of wheats for broilers, from 12.3 to 13.1 MJ/kg in this example, but also approximately halve the variability in wheat feeding value. This has important economic consequences to feed formulation and the safety margins which are often routinely incorporated.

Similarly, **Table 3** summarises the results of various digestibility trials in the UK, Canada and Australia where variations in pig DE values of between 1.5-1.6 megajoules/kg DM have been recorded between high and low energy samples in the more comprehensive studies.

Using this data it can be calculated that the difference between feeding a low or high energy sample in a pig finishing ration containing 50 per cent wheat could be as much as 40g/day liveweight gain on a restricted feed regime and 5 per cent in feed conversion for animals fed ad-lib.

Variability in the feeding value of wheat by-products tends to be even greater than in the cereal itself - differences determined predominately by the efficiency of the milling process. One trial involving various wheat by-products (bran, wheat feed etc.) found a range in pig DE of 3.7MJ/kg DM which highlights the problems facing feed compounders attempting to source wheat by-products with a consistent feeding value.

The recognition of the potential for specifically designed feed enzymes for pig rations has been one of the most exciting developments to occur in the pig industry in recent years. New product developments enable improved digestibility of feed across an increasingly wide range of ration formulations - ultimately leading to profitable performance improvements, feed cost savings, or both.

At present, usage of enzymes in pig feeds lags behind that of poultry and this is partly due to the contrast in the industry structure. The more integrated poultry industry allows more rapid uptake of new technology.

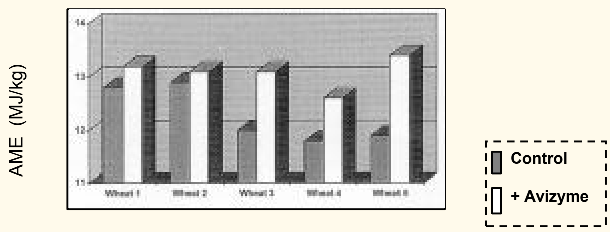
Also, many companies in the pig industry have found responses too variable when applying products developed for poultry into pig feed.

Bolstered by its highly successful research work on developing enzyme use for high cereal-based poultry diets (over 95 per cent of UK broiler feed is supplemented with enzymes), Finnfeeds International, who pioneered the technology, has a team developing enzyme products specifically for the pig industry.

By way of example, **Table 4** shows recent results from a trial at the UK Meat and Livestock Commission's pig unit. Pig performance on simple wheat-based diets was significantly improved by enzyme addition, offering considerable cost savings compared to conventional diets offered during this age/weight period in commercial practice (25.6 p/kg gain versus 41.2p/kg gain).

For the feed trade, the use of the latest enzyme technology means compounders can now take full advantage of competitive prices and, in relevant market places, satisfy consumer pressure for more 'natural' animal feeds based heavily on cereals.

AME variability with and without enzyme across five different wheat samples included at 80% of broiler diet.



	Mean AME (MJ/kg)	Range	Std Deviation
Control	12.3	11.8 – 12.9	0.53
+ Avizyme	13.1	12.6 – 13.4	0.29
Avizyme effect	+6.5%		- 45%

(source: Finnfeeds Research Report 1200.Can.95.06)

AME variability with and without enzyme across five different wheat samples included at 80% of broiler diet.

	Wheat 1	Wheat 2	Wheat 3	Wheat 4	Wheat 5
Control	12.8	12.9	12.0	11.8	11.9
+ Avizyme	13.2	13.1	13.1	12.6	13.4

■ **Base data from which graph is generated**

Figure 3

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