MAXIMISING THE USE OF MILLING BY-PRODUCTS IN SWINE FEEDS

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Introduction

Wheat and rice by-products are key components of swine feeds world-wide and of particular importance in the Asia-Pacific region. Taking a global estimation of wheat production at 570 million tonnes per annum (Grain Market Report 251, October 1996) and assuming around two thirds of this is directed into human food, and is therefore subsequently processed into wheat flour (Kent and Evers 1994), this implies an approximate potential yield of 75 million tonnes of wheat by-products each year ('bran', 'middlings', 'pollard' etc.). World production of paddy rice is similar to that of wheat (Kent and Evers 1994) and corresponding estimates for the annual global availability of rice bran range from 40-45 million tonnes (Farrell 1994).

These milling by-products are therefore a tremendous potential resource of animal feed and the pig is digestively the best equipped monogastric to deal with them. Inclusion rates of milling by-products for growers, finishers and sows are commonly in the range 15-30% in many countries.

Despite their abundance and widespread use these materials offer a number of challenges in commercial feed formulation and, ultimately, to the pig's digestive system. This summary examines some of these and draws attention to recent work on the use of appropriate in-feed enzymes to potentially increase their feeding value and/or inclusion level. The net effect would be an increased opportunity to reduce the costs of swine production.

Rice and wheat by-products - properties and feeding value

There are four broad categories of fibrous by-products made available to the animal feed industry by rice and wheat millers. These are wheat pollard; wheat bran; unextracted rice bran and solvent extracted rice bran. The feeding value of these products for swine is heavily influenced by their dietary fibre content and composition (Table 1). These predominantly insoluble plant cell fibres found in the outer (aleurone) layers of the grain (Fig 1), not only enclose or bind potentially useful nutrients they also interfere with the digestion and absorption of nutrients from other raw materials in the diet (e.g. amino acids, fats, minerals). These detrimental effects on digestibility are particularly apparent at the ileal level, re-emphasising the importance of hindgut fermentation to apparent faecal digestibility in the pig *(Tables 2 and 3.)* Dietary fibres (both soluble and insoluble) are also known to have a high capacity to hold water, together with dissolved nutrients. This feature potentially reduces not only nutrient availability but also voluntary food intake (Dierick and Decuypere 1994, Kyriazakis and Emmans, 1995).

Figure 1: Cross section of wheat showing bran layer (top) and endosperm (Courtesy of VTT Biotechnology and Food Research)

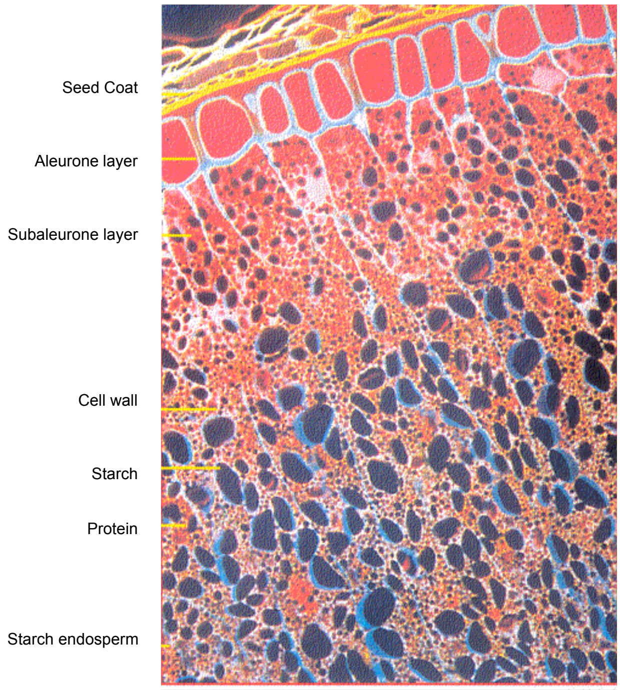

Figure 2: 3-dimensional structure of an endo- 1.4-ß-xylanase from Trichoderma longibrachiatum (Courtesy of Cultor Technology Centre and the University of

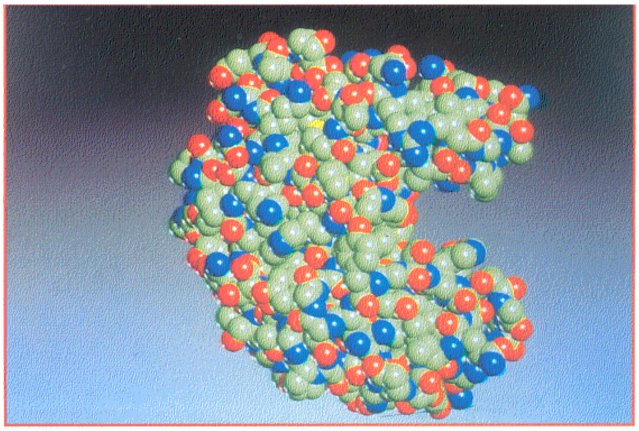

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Table 1: Average chemical composition and energy values for corn compared to wheat and rice milling by-products

	Corn	*Wheat by-products*		*Rice by-products*	
		Pollard	*Bran*	*Extracted*	*Unextracted*
Starch (%)	~62	20-40	10-20	~23	~20
Fat (%)	~ 4	~ 4	~ 4	~ 2	~16
Crude protein (%)	~ 9	~16	~16	~16	~14
Total dietary fibre* (%)	~10	~27	~36	~22	~16
Total arabinoxylans (%)	~ 4	~15	~21	~11	~ 8
(% insoluble)	(94)	(97)	(99)	(97)	(96)
NE** for pigs (kcal/kg)	2545	1530	1290	1340	2550
DE for pigs (kcal/kg)	3530^{a}	3370-2605	2520^{c}	3450^{c}	
		Mean 2965^{b}			

*Non starch polysaccharides plus lignin **CVB (1995) ^{a}NRC (1988); ^{b}Batterham et al (1980); ^{c}Farrell and Hutton (1990), assuming 90% dry matter content.

Table 3: Mean ileal digestibility of diets based on corn/soya or corn/soya + 20% unextracted rice bran. Diets were isocaloric (NE) and formulated to contain similar levels of ileal digestible amino acids. Schulze 1996 (unpublished), 60kg pigs

Ileal digestibility (%)	*Corn/Soya*	*Corn/20% Unextracted rice Bran/Soya*
Dry matter	74.3 ± 0.9	66.1 ± 2.6
Crude protein	75.6 ± 2.1	68.6 ± 4.6
Ash	29.7 ± 5.5	14.9 ± 5.9

Table 4: Effect of xylanase addition to a corn based diet containing 25% wheat pollard*. Faecal digestibility (%). Pigs 40-45kg bodyweight. Diets calculated to be isoenergetic (DE, 3585 kcals/kg) and with the same levels of digestible lysine (0.9%)

	Corn control	*Corn/wheat pollard* control*	*Corn/wheat pollard + xylanase***
Protein (%)	82.6^{a}	71.1^{b}	79.2^{a}
Energy (%)	86.9^{a}	73.3^{c}	80.2^{b}
ED (measured, kcal/kg)	3465	3060	3350
Phosphorous (%)	81.2^{a}	71.0^{b}	77.5^{ab}

*Wheat pollard: Starch 19.3%; NSP 31.5% (95% insoluble) $^{a-c}$P < 0.05
**Xylanase enzyme

Table 2: Ileal and faecal digestibility of nutrients (%) in diets containing 76% wheat, 76% wheat/wheat pollard (50:50) or 76% wheat/wheat bran (50:50) (Yin et al., unpublished)

Diet	*Wheat*	*Wheat/wheat pollard (50:50)*	*Wheat/wheat bran (50:50)*
NSP* level %	8.6	13.5	17.3
AX** level %	5.0	8.0	10.5
Ileal			
Dry matter	77.3^{a}	67.3^{b}	59.4^{c}
Crude protein	80.7^{a}	75.7^{b}	72.0^{c}
Energy	78.7^{a}	68.3^{b}	59.6^{c}
Faecal			
Dry matter	89.0^{a}	81.6^{b}	75.8^{c}
Crude protein	90.3^{a}	87.5^{b}	88.1^{b}
Energy	89.7^{a}	81.9^{b}	75.9^{c}

^{abc}Least square means in the same row with different superscript differ (P < 0.001); *Non starch polysaccharide and **Arabinoxylan contribution from the wheat/wheat by-product fraction of the ration

Milling by-products are renowned for their potential variability and the first step in their successful use in monogastric diets is a regular and effective 'screening' by proximate analysis. Particular attention is given to fibre level (as measured by crude or neutral detergent fibre methods), ash content (particularly important with rice by-products to indicate degree of hull contamination), protein and oil level. Predictive equations of feeding value for both poultry and swine incorporate many, or all, of these factors (e.g.Batterham et al 1980; Creswell 1988; Farrell 1994). For wheat by-products measurements of bulk density also contribute usefully to estimates of DE (Batterham *et al* 1980).

The potential for use of in-feed enzymes with rice and wheat by products

Arabinoxylans are the predominant cell wall NSPs in both rice and wheat by-products, comprising around 60% of the total NSPs present (Table 1). Xylanase-based enzyme systems are therefore the most appropriate for in-feed use with these raw materials. Such xylanases must be carefully pre-selected to be stable and active at the pH's and temperature found in the digestive tract of the pig. To be fully effective the enzyme must function in the stomach or very efficiently in the small intestine, or preferably in both, given the relatively limited time available for enzyme action. The chosen xylanase must also have a high affinity for both soluble high molecular weight arabinoxylans, which create a viscosity problem in the gut contents, and insoluble arabinoxylans in aleurone cell walls which enclose and complex with potentially useful nutrients. Last, and by no means least, the enzyme must be able to survive the rigours of the standard conditioning and pelleting process in the feed mill.

Pig trials - recent experiences

Digestibility trials with corn based diets containing 25% wheat pollard in the USA indicated improvements in energy, protein and phosphorus digestibility when a xylanase product was added to mash diets *(Table 4.)*

An indication that the xylanase has a potential for improving the physical properties of both soluble and insoluble fibre fractions, and thereby influencing voluntary food intake, is provided by recent studies from the USA looking at the addition of wheat pollard to corn-based diets for young pigs (9-20kg, *Table 5)*. In this age of pig the physical constraints imposed by fibre, in particular its water holding capacity, make it a useful model to investigate the effectiveness of various enzyme combinations. In this trial

Table 5: The growth and feed intake response of young pigs (9-20kg) on corn diets containing 30% wheat pollard* +/- xylanase. Corn control DE 3390 kcal/kg; Corn/wheat pollard DE 3155 kcal/kg. Digestible lysine in both diets 1.1 %

	Corn control	*Corn/wheat pollard* control*	*Corn/wheat pollard* + xylanase*
Daily gain(g)	522^{a}	441^{b}	491^{ab}
Daily feed(g)	773^{a}	656^{b}	765^{a}
FCR	1.48	1.51	1.56

*Starch 36.4%; NSP 20.5% (95% insoluble) ^{a,b}P<0.05

Table 6: Recent research trials with a xylanase based enzyme system in the Asia Pacific region

(a) Thailand (Ref 9300. THAI. 96. 11) Corn diets + 15% rice bran; 46 – 92kg

	Corn/rice bran control	Corn/rice bran + xylanase*	Improvement
Daily gain(g)	700	741	+ 6%
Daily feed(g)	2177	2092	- 4%
FCR	3.10^{a}	2.82^{b}	+ 9%
S.D. for finish Wt(kg)	6.61	5.58	+ 16%

$^{a-b}$P<0.05 *Xylanase enzyme

(b) China (Ref 9300. CHI. 96. 14) Corn vs corn/pollard diets (42:58); 37 – 90kg

	Corn control	Corn/pollard control	Corn/pollard + xylanase*
Daily gain(g)	773^{a}	697^{b}	726^{ab}
Daily feed(g)	2463	2339	2367
FCR	3.19	3.36	3.26

$^{a-b}$P<0.05 *Xylanase enzyme

(c) Philippines (Ref 9300. PHIL. 97.15) Corn/pollard (10%) vs corn/pollard (20%); 39 – 81kg

	Corn/low pollard control	Corn/high pollard control	Corn/high pollard control + xyanase*
Daily gain(g)	696	659	696
Daily feed(g)	2020	2020	1920
FCR	2.89^{ab}	3.07^{b}	2.76^{a}
S.D. for finish Wt(kg)	8.2	9.5	7.7

$^{a-b}$P<0.05 *Xylanase enzyme

voluntary food intake in the corn/pollard diet was increased by 17% after addition of xylanase.

Similarly encouraging results in growing/finishing pigs have been reported from recent trials in the Asia Pacific region, using this particular xylanase in corn/soya diets containing rice or wheat by-products *(Table 6.)* Beneficial effects have been shown, not only on growth and feed utilisation, but also on the uniformity of growth. All of these factors contributed to improved costs of production with use of the enzyme.

Conclusions

Rice and wheat milling by-products are a valuable resource in animal feeds worldwide. To fully exploit their potential as swine feeds requires diligent attention to quality control, in order to more accurately appraise their nutritional value. Appropriately researched in-feed enzymes (particularly endo-xylanase) appear to offer an opportunity to both increase their feeding value and reduce their inherent variability.

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