Reducing feed cost but not performance

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The protein producing industries and consequently the animal feed industry continue to undergo huge changes and challenges. Feed represents in the order of 70% of the cost of production in poultry operations.

Its consistency, quality and cost can thus have a huge economic impact on individual producers. As a result of this, a proper understanding of the technical, quality and economic aspects of the business are essential to maintain and grow the business in what is a challenging environment.

Asian poultry markets are very dependent on imported raw materials for their production. Some markets, such as South Korea and Japan, already import more than approximately 70% of their grain.

Poultry consumption

Several Asian economies are exhibiting strong growth and with this, increasing the disposable incomes of large percentages of their populations. It is a well known fact that as a society become more affluent protein consumption (eggs and meat) increases.

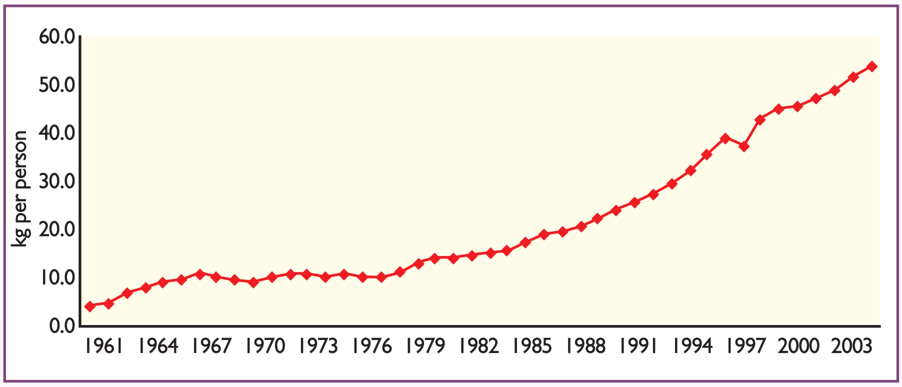

Fig. 1. The Chinese meat consumption revolution.

Meat consumption has been increasing in developing countries by about 6% per annum over the past decade. China, for instance, has had a three fold increase in meat consumption per capita from 1960 through to 2004 (Fig. 1.)

In India, where meat (poultry) consumption is currently only 1.8kg per head per annum, poultry meat production is expected to increase by 16% in 2006 to 2.2 million tonnes from the predicted 1.9 million tonnes in 2005.

Table 1. Illustrative formula showing potential cost savings through the use of by-products in a broiler diet.

Ingredients	Formula A (g/kg)	Formula B (g/kg)	Formula C (g/kg)
Corn	654.0	665.8	200
Soybean meal	220.0	290.0	170.0
Corn gluten meal	15.0	-	-
Limestone	10.0	15.5	10.0
DCP	13.0	6.0	5.0
Palm oil	25.0	10.0	30.0
Alimet	1.0	0.5	1.0
Premix, vitamins, minerals	10.0	10.0	10.0
Fish meal	50.0	-	50.0
Rice bran	-	-	80.0
Palm kernel meal	-	-	100.0
Broken rice	-	-	41.8
Copra meal	-	-	70.0
Cassava	-	-	80.0
Sesame meal	-	-	100.0
Allzyme SSF	-	0.2	0.2
Salt	2.0	2.0	2.0
Total cost/tonne (US$)	**270.51**	**259.53**	**221.36**
Savings/tonne (US$)	**-**	**10.98 (A-B)**	**49.15 (A-C)**

The report, while stating that India is currently self sufficient in corn, anticipates that by 2010, demand will outstrip supply.

These trends go some way to explain the trends in cereal production for an ever expanding population as illustrated in Fig. 2.

What is critical to note, however, is that the underlying trend of per capita production of cereals remains the same.

The question is whether this trend will continue. If, for example, India were to increase its poultry consumption by 10kg per head per annum, this represents an increased feed requirement of approximately 40 million tonnes per annum. This growth, and the changing nature of animal production, have resulted in world compound feed production of an estimated 614 million metric tones (MMT) in 2004 and 742 million tones by 2014 rising to 1,527 million tonnes by 2050.

Ultimately, the question is where is this additional grain going to come from? India has already been cited as one market in Asia where demand will overtake supply in coming years. China is currently a net exporter of corn, exporting in the region of 7.5 million tonnes into the Asia Pacific region but this may be depleted within the next three years. At present Asian countries import 44% of the world's traded coarse grains and about 61% of the imported corn.

A brief study of the above figures shows how Asia Pacific markets are exposed to international pricing. This heavy dependency on imported raw materials to satisfy domestic food production shows how directly vul-

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nerable certain markets are to the price of commodity products such as corn and soy.

Prasad and Chandra (1980) support this view and state that sourcing locally produced raw materials reduces the exposure that these economies have to environmental and market fluctuations. Given the volumes involved, transportation costs also become a critical factor particularly given the current environment of ever rising crude oil prices.

The real question that has to be addressed is can these economies reduce their dependency on imported raw materials? Choct (2005) states that improving the utilisation of unconventional raw materials and by-products can help address the growing gap between meat consumption and grain production.

By increasing the use of locally produced raw materials in diets, while maintaining animal performance, will allow significant cost savings in diets. Raghavan (2004) takes a sample formulation (Table 1) that includes a significant inclusion of non-conventional raw materials such as palm kernel meal, broken rice, copra meal and sesame meal. While it is an illustrative formulation, it shows quite clearly that consideration of these raw materials can reduce the cost of the diet by up to 20% and perhaps even 25%. While recognising there are a significant number of technical concerns that need to be answered before we can proceed, the economics of production and the reduction in exposure to business risk makes a compelling case for further examination even if the physical performance does not completely match those of a corn soy diet.

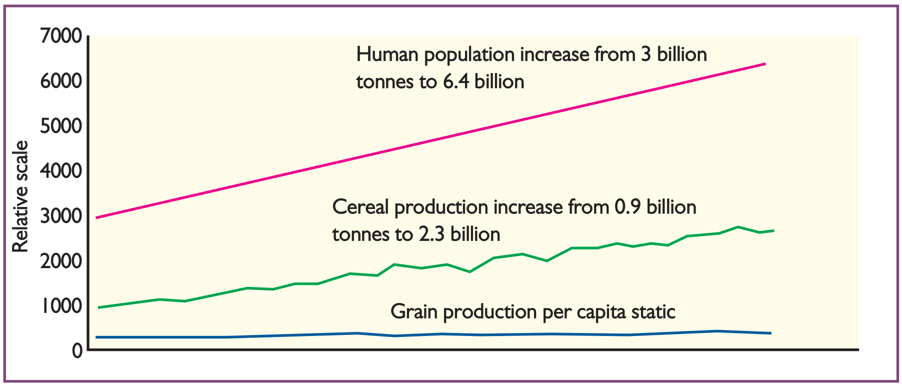

Fig. 2. Population growth, grain production and grain production per capita from 1961 to 2001.

Table 2. Protocol for evaluating potential feed ingredients (Romo and Nava, 2005).

1. Assess availability
   - Source.
   - Quantity.
   - Processing and handling.
   - Minimum amount and cost to justify the process.
   - Logistics: collection centre and transportation.
2. Identify basic nutrient profile
   - Literature review and ingredient database.
   - Proximate analysis of serial samples.
   - Digestible or metabolisable energy estimated with equations.
   - Preliminary formulations to target potential uses.
   - Determine preliminary cost effectiveness.
3. Perform preliminary animal assay
   - Use inclusion levels far above normal use.
   - Always include a control.
   - Use most susceptible animals, challenge with marginal level of the major nutrient.
4. Perform detailed nutritional characterisation
   - Amino acid analysis and fatty acid analysis if protein and fat content, respectively, are of importance, ME assay (if possible).
   - Digestibility of nutrients, in vitro and in vivo.
   - Toxins and anti-nutritional factors.
5. Conduct controlled animal trial
   - Use inclusion levels that would normally be expected.
   - Long term trials to evaluate performance, toxin accumulation.
   - Meat quality, off flavours, taste, residues.
6. Conduct field trial
   - Ideally use two treatments with and without the ingredient.
   - Evaluate on large scale. Quality of faeces, quality of carcases.
7. Address manufacturing issues
   - Storage: determine oxidation curve.
   - Other issues: ventilation needs, special containers, piling limitations.
   - Flow in silos and bins.
   - Grinding, particle size.
   - Mixing, dosing, timing, ingredient interactions, conditioning, pelleting and others.
   - Equipment cleaning and sanitation, cross contamination.
8. Engage in continuous quality improvement
   - Generate database of laboratory and performance results.
   - Improve feed ingredient process.
   - Improve processes at the feed mill.
   - Improve using enzymes: those available now and those under development.

Overcoming the challenges

Romo and Nava (2005) published a comprehensive methodology for the evaluation of raw materials for inclusion in poultry diets as shown in Table 2.

Huang and Reddy (2005) state that more research is required to characterise the chemical structures of these alternative dietary sources in order to increase their use as an efficient alternative energy source. They also mention the use of biotechnology such as enzymes derived from solid state fermentation.

A considerable amount of work has been conducted to date examining ways to increase the digestibility of a number of different by-products using these solid state fermentation derived enzymes. Solid state fermentation enzymes are produced by carefully selected strains of fungi that are grown on specific substrates and express a range of enzyme activities known as a natural enzyme complex. One of the key advantages of this technology is that it produces a wide range of enzyme activities but also natural synergies exist between the enzymes in the complex.

Wu et al (2004) found that Allzyme SSF (an enzyme produced by solid state fermentation) compared to a cocktail enzyme (consisting of equivalent enzymes and activities) and a single phytase, released significantly more phytate P, reducing sugars and amino nitrogen in both wheat and corn based diets.

Allzyme SSF is produced using a wheat bran substrate but has been successfully used on a wide range of diets. Ribeiro et al (2003) used Allzyme SSF in a diet containing 10% rice bran. The authors state that in countries where large amounts of rice bran is produced, Allzyme SSF could be used to

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Feedstuffs	In the diet (%)	Prerequisite	Enzymes needed	Reference
Palm kernel meal	20	None	None	Hutagalung (1980)
	30-40	Balance diet by addition of methionine and lysine	Multi enzymes (Allzyme SSF & mannan degrading enzyme)	Sundu et al (unpublished)
Copra meal	20	None	None	Mahadevan et al. (1957)
	30-40	Balance diet by addition of methionine and lysine	Multi enzymes (Allzyme SSF & mannan degrading enzyme)	Thomas & Scott (1962); Sundu et al (unpublished)

Table 3. Recommendations for using palm kernel meal and copra meal in broiler diets (Sundu and Dingle, 2003).

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enhance the utilisation of the raw material. Results would indicate that there is further scope for higher inclusion rates of this raw material. Research is underway to examine this.

Other studies have also been carried out, most notably at the University of Queensland, Australia, using palm kernel meal and copra meal. In the first paper Sundu and Dingle (2003) found that diets containing 30 and 40% palm kernel meal plus Allzyme SSF gave good results when the diet was carefully balanced with lysine and methionine.

Similarly, they found that 30 to 40% copra meal could be used with Allzyme SSF in a balanced diet again taking into consideration key limiting amino acids. Their recommendations are summarised in Table 3.

In a later paper, Sundu et al (2004) highlighted some of the inherent difficulties with making recommendations with by-products being used as raw materials in poultry diets. Despite significant improvements in dry matter digestibility (6%), weight gain and FCR with the inclusion of Allzyme SSF in diets with high levels of copra meal they were not able to replicate the findings of the previous year. They attributed this to a change in quality of the copra meal possibly due to overheating during the drying and oil extraction process.

In a further study Sundu et al (2005), found that increasing levels of palm kernel meal (20, 30 and 40% in the diet of broiler chicks from 5-15 days) had a detrimental effect on FCR, dry matter digestibility and NDF digestibility (Table 4).

The addition of Allzyme SSF reversed this and successfully improved feed efficiency, dry matter and NDF digestibility (Table 5).

As Sundu et al have highlighted, variability of a by-product can be a major factor influencing animal performance and as a result it becomes less attractive to use. Being able to overcome this issue is critical for the raw materials greater inclusion in diets. The other issue is to be able to safely deal with the anti-nutritional factors associated with the particular substrate.

Alltech is developing solid state fermentation technology for the production of enzymes in order to produce natural enzyme complexes that are better suited to the types of substrate found in poultry and other monogastric diets. Following the success of Allzyme SSF (which uses wheat bran as the solid substrate) on a wide range of raw materials both conventional (corn, wheat and soy) and by-products (such as wheat and rice bran, palm kernel meal, copra meal), questions have been asked about whether further improvements can be made. With the rise in production of industrial ethanol the by-product, dried distillers grains solubles (DDGS) will become increasingly available as a by-product and Alltech have already started producing a natural enzyme complex, Allzyme DDG matched to this substrate. The production process uses DDGS for the fungal culture to produce the complex.

Studies conducted at the University of Kentucky are promising and further commercial evaluation studies are ongoing in the USA. Diets containing 30% DDGS with Allzyme DDG at both one and two kilos per tonne showed significant improvement in terms of nitrogen digestibility over diets with just 30% of DDGS and no enzyme. At one kilo per tonne of Allzyme DDG with 30% DDGS similar levels of nitrogen digestibility was observed and two kilograms per tonne even greater levels were achieved.

Diet cost would be significantly reduced, if locally sourced by-products were able to be used to a greater extent in poultry diets.

This represents a tremendous opportunity particularly in countries that are highly dependent on imported raw materials to reduce their business risk and to improve profitability. Selection and use of by-products has to proceed in a careful manner and there are many tools to overcome what have been barriers to their use to date.

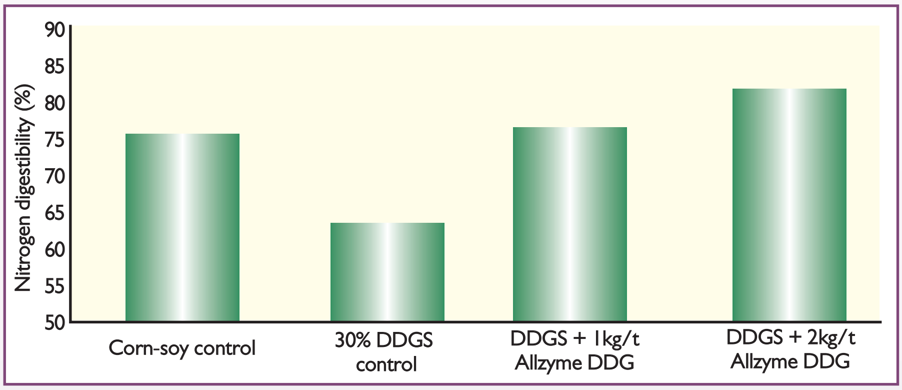

Fig. 3. Effect of SSF enzymes (Allzyme DDG) on nitrogen digestibility in broiler chicks fed diets containing 30% DDGS (Pierce, personal communication).

One such tool is the use of natural enzyme complexes derived from solid state fermentation (for example Allzyme SSF).

These solid state fermentation derived complexes have demonstrated significant capacity to alleviate some of the anti-nutritional factors usually associated with such raw materials.

As the technology develops over the coming years and as our understanding increases a 25% saving in feed costs may turn out to be a conservative estimate. ■

Table 4. The effects of palm kernel meal (PKM) level on the response of broiler chicks, day 5-15 (Sundu et al, 2005).

Level of PKM	0%	20%	30%	40%
Weight gain	297	296	291	296
Feed intake	374^{c}	396^{a}	378^{bc}	393^{ab}
FCR	1.26^{b}	1.34^{a}	1.30^{a}	1.33^{a}
DM digestibility	81.8^{a}	77.0^{b}	70.6^{c}	65.9d
NDF digestibility	81.8^{a}	77.0^{b}	70.6^{c}	65.9^{d}
Viscosity (cP)	2.67^{a}	2.02^{b}	1.86^{c}	1.81^{c}

$^{abcd:}$ *Row means with the same superscript are not significantly different (P<0.05)*

Table 5. SSF enzymes significantly improve FCR and digestibility in 5-15 day broilers fed 40% palm kernel meal (Sundu et al, 2005).

Parameter	Control	Allzyme SSF
Weight gain (g)	290	294
FCR	1.37^{a}	1.27^{b}
Dry matter digestibility	73.1^{a}	73.6^{b}
NDF digestibility (%)	43.2^{b}	47.3^{a}

Means not sharing a letter differ significantly (p<0.05)