

## Improving soya utilisation in monogastrics:

# Maize-soya diets with $\beta$ -mannanase

BY MARK JACKSON, PHD

**F**eed enzymes are not new to the poultry and swine industries, but interest in their cost-saving potential and capacity to reduce pollution from animal production continues to grow. Xylanase in wheat-based diets and  $\beta$ -glucanase (beta-glucanase) in barley-based diets improve digestibility and reduce gut viscosity. Such enzymes therefore are used extensively where these feedstuffs predominate, as in northern Europe and parts of North America and Oceania. Phytase is used in a variety of diets to minimise phos-

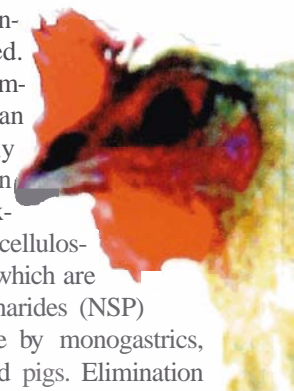
phorus in the manure. Nonetheless, enzyme usage in monogastric diets based upon maize-soya (yellow corn-soybean meal) remains relatively limited.

Recent research examining energy utilisation, body weight uniformity and parameters related to health status show that a  $\beta$ -mannanase (beta-mannanase) feed additive can counter the anti-nutritional effects of Bmannans in soya or soybean meal in practical diets for broilers, turkeys and swine.

Although corn is relatively well digested by monogastric animals, energy

in soybean meal is only 50-60% utilised. Why is the energy component of soybean meal so poorly utilised? Soybean meal contains approximately 22.7% hemicelluloses (Chesson, 1987) which are non-starch polysaccharides (NSP) virtually indigestible by monogastrics, including poultry and pigs. Elimination of these indigestible components enhances the feeding value of soybean meal (Coon *et al.*, 1990).

One component of NSP is  $\beta$ -mannan, a galacto-mannan which is higher in concentration in soybean meal than on other commonly used feedstuffs. The  $\beta$ -mannan has several negative physio-



**Table 1.**

Interaction between dietary energy and enzyme on growth and feed efficiency in various species.

	Enzyme*	High energy		Low energy	
		-	+	-	+
Broilers <sup>1</sup>	BW (kg)	2.21 <sup>b</sup>	2.25 <sup>a</sup>	2.17 <sup>c</sup>	2.23 <sup>ab</sup>
	Feed:gain	1.86 <sup>b</sup>	1.81 <sup>a</sup>	1.93 <sup>c</sup>	1.84 <sup>ab</sup>
Turkeys <sup>2</sup>	BW (kg)	14.77 <sup>ab</sup>	14.90 <sup>a</sup>	14.25 <sup>c</sup>	14.61 <sup>b</sup>
	Feed:gain	2.83 <sup>a</sup>	2.74 <sup>b</sup>	2.79 <sup>c</sup>	2.73 <sup>b</sup>
Swine <sup>3</sup>	ADG (g)	553		543	558
	Feed:gain	1.70 <sup>y</sup>		1.76 <sup>x</sup>	1.68 <sup>y</sup>

\*100 MU/ton (million units per ton)  $\beta$ -mannanase (Hemicell® from ChemGen Corporation).

<sup>1</sup>145-day trial using 1200 straight-run broilers with 143 kcal/kg difference between low and high energy diets (McNaughton, 1995).

<sup>2</sup>18-week trial using 924 male and female turkeys with difference between low and high energy diets ranging from 94 kcal/kg (starter diet) to 41 (finisher diet) kcal/kg (McNaughton, 1995).

<sup>3</sup>21-day trial using 117 mixed sex pigs starting at 13.62 kg with 100 kcal/kg difference between low and high energy diets and enzyme added to low energy diet only (Petty *et al.*, 2001).

<sup>a-c</sup> Means within rows not sharing a common superscript are significantly different (P<.05).

<sup>x-y</sup> Means within rows not sharing a common superscript are significantly different (P<.10).

*Dr. Jackson is a poultry nutritionist and technical manager of ChemGen Corporation, an international feed additive supplier based in the USA, which may be contacted at 211 Perry Parkway, Gaithersburg, MD 20877, tel +1 301 330 4101, fax +1 301 948 5866, website www.chemgen.com. Dr. Jackson may be contacted by e-mail at mjackson@chemgen.com.*

**Table 2.**

Effect of medication and  $\beta$ -mannanase on performance and lesion scores of broilers provided with corn-soybean meal diets (experiment).

Infection <sup>1</sup>	Treatment Medication <sup>2</sup>	Enzyme <sup>3</sup>	Gain	Feed:gain*	Lesion score		Mortality
			8-21 days (g)	8-21 days	<i>E. acervulina</i>	<i>E. maxima</i>	8-21 days (%)
No	Yes	No	540 <sup>a</sup>	1.446 <sup>a</sup>	0.00 <sup>c</sup>	0.00 <sup>c</sup>	0.0
No	Yes	Yes	548 <sup>a</sup>	1.424 <sup>a</sup>	0.00 <sup>c</sup>	0.00 <sup>c</sup>	1.25
Yes	No	No	429 <sup>c</sup>	1.704 <sup>c</sup>	1.38 <sup>a</sup>	1.56 <sup>a</sup>	8.75
Yes	No	Yes	490 <sup>b</sup>	1.536 <sup>b</sup>	1.16 <sup>ab</sup>	1.44 <sup>a</sup>	3.75
Yes	Yes	No	522 <sup>a</sup>	1.447 <sup>a</sup>	1.03 <sup>b</sup>	0.88 <sup>b</sup>	1.25

\*Adjusted for mortality.

<sup>1</sup>Birds challenged at 8 days of age with 75,000 *Eimeria acervulina* and 1250 *E. maxima* oocysts per bird and at 11, 12, and 13 days with 10<sup>8</sup> cfu *Clostridium perfringens*, all by oral gavage.

<sup>2</sup>BMD (50 g/ton) and Sacox (60 g/ton).

<sup>3</sup>100 MU/ton  $\beta$ -mannanase (Hemicell® from ChemGen Corporation).

<sup>a-c</sup> Means within columns not sharing a common superscript are significantly different (P<.05).

Source: Mathis, 2000-2001.

## Improving soya utilisation in monogastrics: Maize-soya diets with $\beta$ -mannanase

logical effects on poultry and swine apart from its poor digestibility. Even low concentrations of  $\beta$ -mannanase have been shown to reduce the rate of glucose absorption from the intestine and consequently carbohydrate metabolism by interfering with insulin secretion and IGF (insulin-like growth factor) production (Nunes and Malmlof, 1992). Other negative effects include decreased nitrogen retention, fat absorption and amino acid uptake, as well as reduced water absorption which results in excess excreta moisture (Kratzer *et al.*, 1967).

### Dietary energy utilisation

Recent experiments have sought to determine how  $\beta$ -mannanase increases the available energy in practical corn-

soybean meal type diets for broilers, turkeys and pigs (Table 1). These experiments involved varying the calculated metabolisable energy (ME) of the diets with and without enzyme treatment.

Growth and feed conversion of broilers fed the low energy diets with the enzyme were the same as those of the high energy diets without the enzyme. In the turkey experiment, low energy diets were formulated by substituting 48% CP (crude protein) soybean meal for 44% CP soybean meal, resulting in diets which were 41 Kcal/kg to 91 kcal/kg lower in ME. Feed conversion was significantly better with the low energy diets with the enzyme, compared to the high energy diets without the enzyme, indicating that the energy improvement

was greater than 41-94 kcal/kg. In a swine experiment, the energy and enzyme were similar to the broiler experiment in their positive effects on feed conversion.

The three experiments show that  $\beta$ -mannanase increases energy utilisation as demonstrated by improved feed conversion and growth. The enzyme additive compensated for energy decreases of 143 kcal/kg ME in broilers and 100 kcal/kg ME in pigs.

### Uniformity in poultry production

Body weight uniformity can be an important criterion in determining profits, especially in poultry production. Comprehensive pen studies were conducted with broilers and turkeys in which every bird was individually weighed in each replicate pen. This procedure was necessary to statistically compare differences in variability among the treatments. A pen study examined mixed-sex broilers at 21, 35 and 49 days of age with 12 replicate pens per treatment. With the  $\beta$ -mannanase enzyme, variability—as determined by co-efficient of variation (CV)—was significantly reduced ( $P < .05$ ) at all ages. At 49 days of age, the CV was reduced from 13.4% to 11.3% as a result of the enzyme, representing a 16% reduction in body weight variability.

In a similar type study, body weight CV of turkey toms was significantly reduced at 21, 42 and 84 days of age ( $P < .05$ ). At 84 days, the CV was reduced from 10.07% to 6.65%, repre-

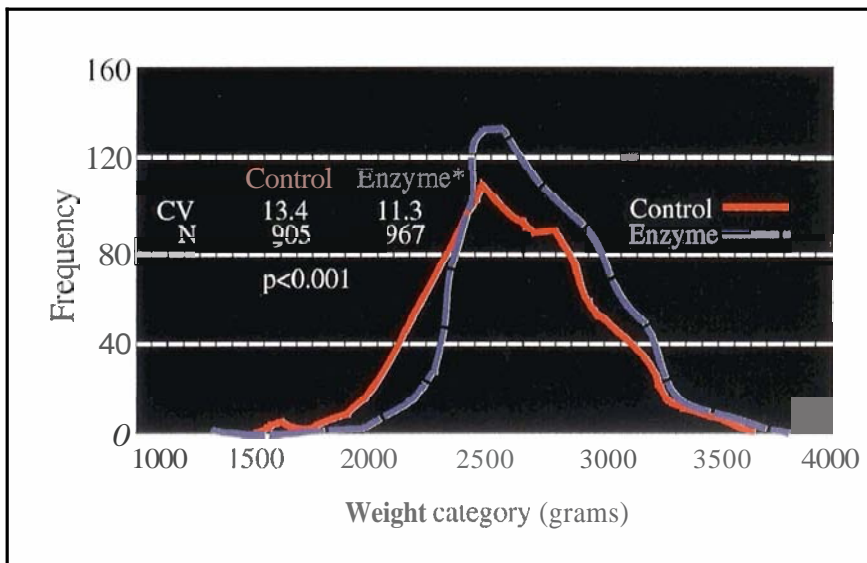


Figure 1. Broilers in 49-day growout—effect of  $\beta$ -mannanase on uniformity of body weight. \*100MU/ton  $\beta$ -mannanase (Hemicell® from ChemGen Corporation). Source: PARC Institute, 1998.

Table 3.

Effect of medication and  $\beta$ -mannanase on performance and lesion scores of infected broilers (Experiment 2).

Medication <sup>2</sup>	Treatment <sup>1</sup> Enzyme <sup>3</sup>	Protein source <sup>4</sup>	Gain	Feed:gain*	Lesion score		Mortality
			0-21 days (g)	0-21 days	<i>E. acervulina</i>	<i>E. maxima</i>	0-21 days (%)
No	No	SBM	640 <sup>b</sup>	1.519 <sup>c</sup>	1.81 <sup>a</sup>	1.19 <sup>a</sup>	0.25
Yes	No	SBM	700 <sup>a</sup>	1.431 <sup>d</sup>	0.63 <sup>b</sup>	0.25 <sup>b</sup>	0.13
No	Yes	SBM	710 <sup>a</sup>	1.447 <sup>d</sup>	1.38 <sup>a</sup>	0.88 <sup>a</sup>	0.13
No	No	ANBY	651 <sup>b</sup>	1.655 <sup>a</sup>	1.31 <sup>a</sup>	0.63 <sup>ab</sup>	0.38
Yes	No	ANBY	692 <sup>a</sup>	1.541 <sup>b</sup>	0.44 <sup>b</sup>	0.31 <sup>b</sup>	0.13
No	Yes	ANBY	689 <sup>a</sup>	1.608 <sup>ab</sup>	1.69 <sup>a</sup>	1.00 <sup>a</sup>	0.38

\*Adjusted for mortality.

<sup>1</sup>Birds challenged at 8 days of age with 75,000 *Eimeria acervulina* and 1250 *E. maxima* oocysts per bird and at 11, 12 and 13 days with 10<sup>8</sup> cfu *Clostridium perfringens*, all by oral gavage.

<sup>2</sup>BMD (50 g/ton) and Sacox (60 g/ton).

<sup>3</sup>100 MU/ton  $\beta$ -mannanase (Hemicell® from ChemGen Corporation).

<sup>4</sup>SBM—corn-soybean meal based diet as in Experiment 1; ANBY—poultry by-product meal used as a protein source; diets containing no soybean meal or other significant source of  $\beta$ -mannan.

<sup>a-d</sup> Means within columns not sharing a common superscript are significantly different ( $P < .05$ ).

Source: Mathis, 2000-2001.

senting a 34% reduction in variability with the use of the enzyme.

What is the nature of these reductions in variability? The frequency distribution from the broiler and turkey experiments can be shown graphically (Figures 1 and 2). It is clear from these studies that the smallest animals are most positively affected by B-mannanase as an additive in practical diets. These studies also suggest that the enzyme is improving growth and feed conversion beyond what may be explained by a simple boost in available energy from the diet.

### Health status

Two broiler experiments were conducted to determine the effect of the enzyme under disease-induced circumstances. In both experiments, eight replications of 14 chicks per cage were assigned to each treatment and grown to 21 days. In Experiment 1, diets containing medication with or without B-mannanase were provided to chicks with or without a disease challenge from 8 days of age to 21 days (Table 2). Infection decreased gain by about 21%, decreased feed efficiency by about 18%, and caused high mortality. The use of medication fully restored performance to normal levels while the enzyme treatment significantly improved performance in the infected birds, but not to the level of the uninfected controls. A similar trend was observed for coccidial lesion scores. Mortality was reduced to uninfected levels by both the enzyme and medication, although differences were not significant.

In Experiment 2, all birds were subjected to a disease challenge as described in Experiment 1. A basal diet devoid of soybean meal and B-mannan but nutritionally equal to the corn-soybean meal diet was included. Both the medication and enzyme significantly improved weight gain in both basal diets (Table 3). Feed conversion was significantly improved by the medication and numerically improved by the enzyme in the B-mannan-free basal diet.

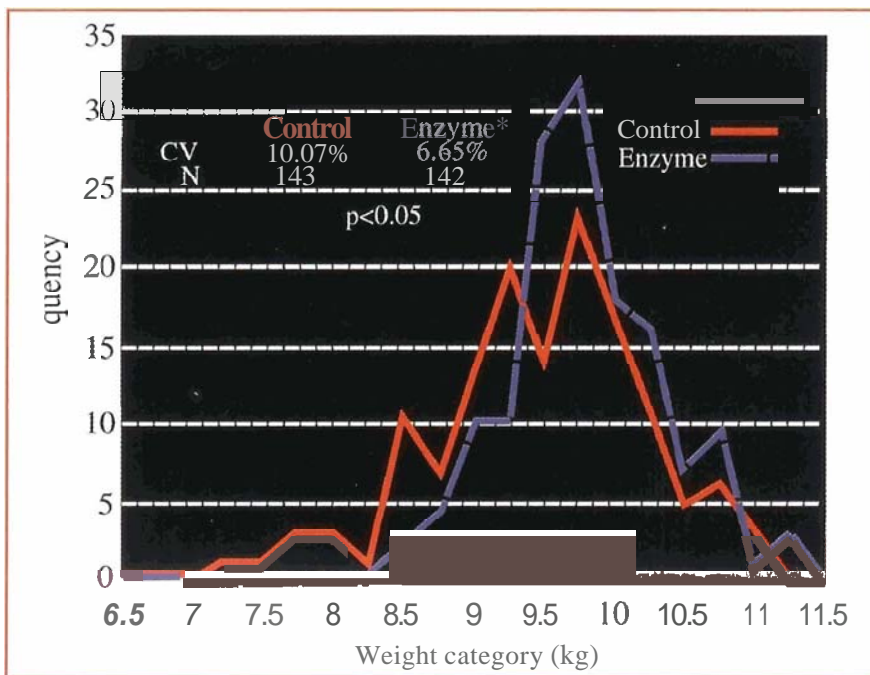


Figure 2. Turkeys in 84-day growout-effect of B-mannanase on uniformity of body weight. \*100MU/ton B-mannanase (Hemicell® from ChemGen Corporation). Source: Southern Poultry Research, 2001.

These data demonstrate that B-mannanase improves the health status of birds by a mechanism other than removal of B-mannan. Although the mechanism is not understood at this time, preliminary *in vitro* data suggests that the enzyme may effectively block bacterial and parasitic invasion of the intestinal lumen.

### Optimising soybean meal

Soybean meal is the predominant source of protein for poultry and swine in many countries. Its energy is poorly utilised (<60%) due to a large NSP fraction. One component of NSP is B-mannan which has several negative physiological effects on poultry and swine. These include reduced glucose, fat, water and amino acid uptake from the intestine. The enzyme B-mannanase counters these known negative effects of B-mannans in broilers, turkeys and swine.

When added to low energy broiler diets, B-mannanase improves feed conversion to that of diets higher in ME. With the enzyme, uniformity of body weight in broilers and turkeys is in-

creases due to increased weights of the smallest individuals in the populations. Disease challenge studies demonstrate that the enzyme improves health status by a mechanism beyond simple reduction of B-mannan in feedstuffs. **fi**

#### References

- Chesson, A., 1987. Supplementary enzymes to improve the utilization of pig and poultry diets. In: Recent Advances in Animal Nutrition. pp 71-89. Butterworths, London.
- Coon, C.N., K.L. Leske, O. Akavanichan, and T.K. Cheng. 1990. Effect of oligosaccharide-free soybean meal on metabolizable energy and fiber digestion in adult rats. *Poultry Sci.* 69: 787.
- Kratzer, F., R. Rajagurer, and P. Vohra, 1967. The effect of polysaccharide energy utilization/retention and fat absorption in chickens. *Poultry Sci.* 46: 1489.
- Leeds, A. R., S. S. Kang, A. G. Low, and I. E. Sambrook, 1980. The pig as a model for studies on the mode of action of guar gum in normal and diabetic man. *Proc. Nutr. Soc.* 39:44.
- Mathis, G.F., 2000-2001. Southern Poultry Research, Inc., Athens, Georgia, USA.
- McNaughton, J.L., 1995. PARC Institute, Easton, Maryland, USA.
- Nunes, C. S., and K. Malmlof, 1992. Effects of guar gum and cellulose on glucose absorption/hormonal release, and hepatic metabolism in the pig. *Br. J. Nutr.* 68: 693.
- Petty, L.A., S.D. Carter, B.W. Senne, and J.A. Shriver, 2001. Effects of Hemicell addition to corn-soybean meal diets on growth performance, carcass traits, and nutrient digestibility of weaning and growing-finishing pigs. *Journal of Animal Science* in press.

**Hemicell®**

**More meat...less cost...the natural way!**

ChemGen Corp • 211 Perry Parkway • Gaithersburg, Maryland 20877 • U.S.A.

Tel: (301) 330-4101 • Fax: (301) 948-5866 Website: www.ChemGen.com • E-mail: info@ChemGen.com