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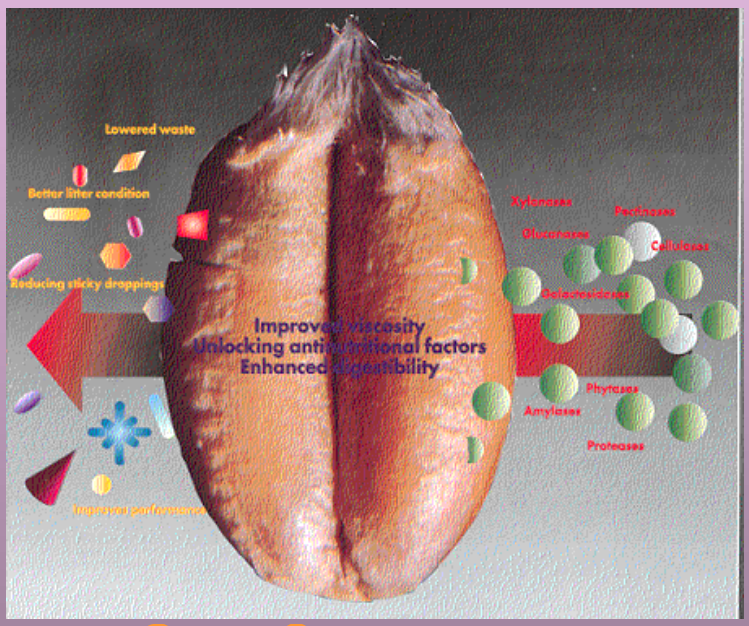

ENZYMES' ROLE IN NUTRITION

Improved viscosity
Unlocking anti-nutritional factors
Enhanced digestibility

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MORE FLEXIBILITY WITH NEW GENERATION OF ENZYMES

The use of in-feed enzymes to improve broiler performance, particularly on wheat and barley-based diets, is now widespread. Most recent market research indicates that in the UK, around 90-95% of all broiler diets contain feed enzymes, and on a world-wide basis as much as 60-70% of wheat and barley-based feeds are enzyme-supplemented.

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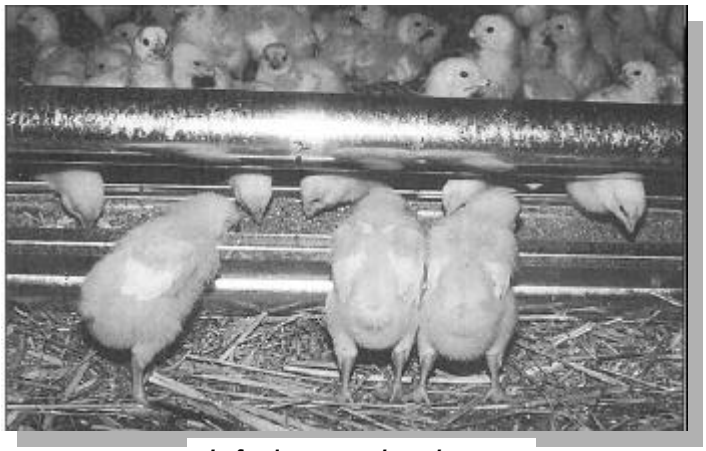

In-feed enzymes have become a key-feature in broiler diets, where wheat and barley are the major cereal sources.

The tremendous growth in this particular application of biotechnology to animal production has accelerated over a relatively short period (4-5 years) and has come about due to the more recent development of feed process stable enzymes which have been specifically designed to function optimally in the gut of the bird.

This paper describes the background of some of the most recent trial work carried out by Finnfeeds International on a new generation of feed enzymes and how the results obtained can be translated into the practical formulation of broiler diets.

Modes of action of feed enzymes

It has well been established that enzymes function by improving the digestion of nutrients in a ration. Work carried out in various research centres has identified effects on gut viscosity as being one of the primary modes of action.

Cereals have a high content of arabinoxylans and mixed-linked ß glucans (Table 1). These are of particular nutritional significance because they make up cereal endosperm cell walls, and in solution in the animals' gut tend to create viscous conditions (i.e. they can form gels). The absolute level of these soluble fibres in the cereal is relevant, but other factors such as the chain-length of the molecule are of equal importance to their gel-forming properties. Harvest conditions are known to have a significant influence on the level and type of soluble fibres found, with early harvest, warm temperatures, and low rainfall being frequently associated with an increase in extract viscosity (e.g. barley, Table 2). Prevailing weather conditions at harvest and cultivar are influencing factors. And as a consequence, cereals which are likely to cause digestive problems in broilers are often difficult to identify with rapidity and cheapness, at our current state of knowledge.

Table 1

TYPICAL COMPOSITION OF CELL WALL MATERIAL (DM BASIS) OF WHEAT, BARLEY AND MAIZE

Component	Maize	Wheat	Barley
Mixes-linked beta-glucans (%)	-	0.8	4.4
Arabinoxylans (%)	4.9	6.0	7.0
Cellulose (%)	2.6	2.5	4.3
Klason lignin (%)	0.6	0.8	2.2

Impact on foregut

The addition of suitable multi-enzyme preparations containing in particular, xylanase and ß-glucanase activities, has a significant impact on foregut digesta viscosity in the broiler. This results in an improvement in nutrient utilisation and subsequent bird performance (Fig. 1). The precise nature of this relationship is important, for it allows predictions to be made about responses to enzyme addition in a variety of circumstances. The relationship between foregut viscosity and animal performance has been found to be logarithmic, hence for example a reduction in viscosity of 90 centipoise units (cps) from 100 to 10 cps should give the same improvement in chick performance as reducing the viscosity from 10 to 1 cps (9 cps).

This implies that low viscosity wheats and barleys should still respond to enzyme supplementation and consequently, enzyme inclusion levels should not be reduced with these low viscosity cereals. Some of the most recent trial data presented here illustrate this point in more detail.

Improvements in nutrient utilisation

Reducing foregut viscosity with exogenous enzyme addition improves nutrient utilisation and animal performance in a number of ways:

Table 2

INFLUENCE OF HARVEST TIME AND WEATHER CONDITIONS ON WATER-EXTRACT VISCOSITY IN OVER 80 BARLEY SAMPLES

	Harvest time		
	Early	Normal	Late
	4.4a	2.7b	2.0b
	Temperature		
Extract viscosity (cps)	Warm	Normal	Cold
	3.9a	2.9b	2.6b
	Rainfall		
	Dry	Normal	Wet
	3.4a	2.7ab	2.6b

a-b P<0.05 Data from Hesselman, 1983.

Table 3

EFFECTS OF AVIZYME (AZ) ON PERFORMANCE AND GUT PARAMETERS IN BROILERS OFFERED DIETS CONTAINING HIGH OR LOW BETA-GLUCAN BARLEYS, 0-21 DAYS

	Maize control	Low beta-glucan barley control	Low beta-glucan barley + AZ	High beta-glucan barley control	High beta-glucan barley + AZ
Daily gain	30.0 a	27.3 b	29.7 a	24.2 c	27.4 b
Feed gain	1.47 b	1.49 b	1.40 c	1.60 a	1.53 ab
Feed intake (g/d)	43.6 a	40.4 b	41.7 ab	38.4 c	40.7 b
Pancreas wt (% BW)	0.411 bc	0.487 ab	0.402 c	0.515 a	0.453 abc
Digesta dry matter (%) 21.0a		16.9 cd	19.3 b	16.5 d	18.0 c
Digesta viscosity (cPs)	1c	13 b	2 c	29 a	3 c
Ileal Digestibility (%)					
Starch	95.7 ab	89.7 c	95.9 ab	94.6 b	96.5 a
Crude protein	87.0 a	74.1 c	83.4 b	69.4 d	80.9 b
Crude fat	83.8 a	76.7 c	80.8 ab	75.4 c	78.8 bc

a-d means not sharing the same superscript differ significantly (P<0.05)
Data from:IRTA, Centre Mas Bove, Spain

1. Increasing the effectiveness of host enzymes

Breaking down the gel-forming characteristics of soluble fibres allows the bird's own digestive enzymes to function more efficiently. This is exemplified by recent studies in broiler chicks where measurements were made of ileal digestibility of various nutrients in the presence or absence of added enzyme (Table 3). Significant improvements in starch, protein and fat digestibility were apparent, and these were associated with a significant lowering of digesta viscosity in the enzyme supplemented groups.

Interestingly pancreas weight, as a proportion of body weight, was increased in the absence of added enzyme suggesting that feedback mechanisms in the bird's gut were stimulating hypertrophy of this organ. This could have implications for the protein economy of the bird, i.e. more protein synthesis directed towards organ growth and endogenous enzyme secretion leaving less available for lean tissue growth. These aspects merit further study to enable them to be quantified more precisely.

Another recent study looking at nutrient digestibility at the terminal ileum has demonstrated improvements in amino acid and energy digestibility in the presence of enzymes (Table 4). In a wheat-based ration, all the major limiting amino acids showed a significant improvement in apparent digestibility, ranging from 8% (lysine) to 36% (cysteine). The differences between digestibility coefficients for each amino acid would include effects on endogenous secretions which would be incorporated into any measurement of apparent digestibility.

2. Alterations in feed passage rate

Addition of suitable erogenous enzymes to feeds has been shown to reduce the water holding capacity of the gut contents, increasing dry matter content (Table 3) and in some studies, increasing feed passage rate. The net effect of these changes is frequently a stimulation of feed intake in the presence of feed enzymes and an overall improvement in feed utilisation and growth.

3. Effects on excreta characteristics

Reducing the dry matter content of the digesta in the gut with added enzymes has a marked impact on excreta volume and composition. In a trial, offering wheat or wheat/barley-based rations to broilers, fresh excreta weights were reduced by 17-28%, corresponding to a reduction in dry matter output of 12-15% (Table 5). This has important implications for nitrogen outputs from broiler units given the additional improvements in protein digestibility that enzymes impart.

The direct production benefits of lower excreta output and reduced faecal dry matter are seen in some broiler trials where

Table 4

EFFECTS OF AVIZYME ON ILEAL DIGESTIBILITY IN A WHEAT-BASED DIET AT 21 DAYS

	Control	+Avizyme	Significance
Foregut digesta viscosity (cPs)	4.7	3.8	**
Energy	67.4	73.1	**
Protein	72.1	77.3	***
Lysine	80.8	87.1	***
Methionine	76.8	84.3	**
Cysteine	48.2	65.6	*
Threonine	65.8	74.4	***

*P<0.05; **P<0.01; ***P<0.001
Data from: Scottish Agricultural College, Auchincruive

KEY POINTS

- In-feed enzymes have become a key feature of broiler diets, where wheat and barley are the major cereal sources.
- One of the major modes of action of an effective enzyme system is to alter the characteristics of the digesta, removing the effects of gel-forming carbohydrates to reduce viscosity and thereby improve nutrient utilisation. Relatively low viscosity cereals still have a potential for cost-effective upgrading with enzyme addition because of the logarithmic relationship between foregut viscosity and bird performance.
- These effects on nutrient digestibility can be quantified by experimentation to allow formulation of diets with reduced cost while maintaining bird performance.

MORE FLEXIBILITY WITH NEW GENERATION OF ENZYMES

Table 5

MEASUREMENTS AT 19-21 DAYS OF EXCRETA OUTPUT IN WHEAT AND WHEAT/BARLEY-BASED DIETS WITH AND WITHOUT ENZYME ADDITION

	Wheat control	Wheat + Avizyme	Wheat/ Barley	Wheat/Barley + Avizyme
Fresh excreta (g)	221 a	184 b	258 c	185 b
Excreta dry matter (%)	42.4 a	45.2 b	39.8 c	47.3 b
Dry excreta (g)	94 a	83 b	102 a	87 b

a-c Means not sharing the same superscript differ significantly
Data from: Lakeside Research Centre, Alberta, Canada

observations on the frequency of hock lesions and breast blisters are recorded. For example, a recent commercial trial on wheat-based broiler feeds in the UK showed a decreased incidence of hock lesions when a feed enzyme was incorporated (50% incidence in control versus 21% in the Avizyme-treated group).

Formulation opportunities using in-feed enzymes

1. Cereal replacement: Several recent studies have investigated the response to reducing levels of high ME cereals in formulations, and replacing them fully or partially with lower ME cereals plus feed enzymes. The attraction of this approach is to allow compounders and integrators to take full advantage of raw material opportunities which may only exist for a limited period but offer considerable scope for feed cost savings, without detriment to bird performance (Table 6).

2. Increasing energy and amino acid availability in cereals: The improvement in energy and amino acid digestion which certain enzyme blends promote (Table 3) can be used in feed formulation to help reduce diet cost without compromising growth performance. A series of experiments have been carried out where diets are formulated using modified specifications for the cereal component, to allow for the presence of feed enzyme. Levels of amino acids and energy in the cereal are sequentially adjusted on the formulation matrix and bird performance measured at each point, in the presence and absence of enzyme. In this way, an approximate "breakpoint' can be established, allowing recommendations to be made about expected uplifts in nutrient availability in specific cereal components. This approach is illustrated from a recent trial in Fig 2.

Whilst it is undoubtedly true that not all of the responses seen to enzyme addition can be attributed solely to improvements in the digestibility of the cereal component, this method does allow a theoretical concept to be incorporated into a practical formulation exercise with a large degree of confidence. Care should be taken, however, to ensure that any changes in specification are tied to the cereal which is the target of the enzyme, and that the enzymes used are capable of giving the assumed improvements. Equally, starting values on the formulation matrix should always be checked beforehand to ensure they are realistic before any potential adjustments are made.

An example of a wheat-based formulation using the listed energy and amino acid 'uplift' figures is shown in Table 7, illustrating the cost-saving potential of this approach. Equally, over-the-top addition of feed enzymes to an existing standard diet will still be favoured as a cost-effective method of increasing performance by many broiler integrators. The flexibility which feed enzymes allow makes either approach equally valid.

Table 6

SEQUENTIAL REPLACEMENT OF MAIZE BY WHEAT, OR WHEAT PLUS ENZYME (AZ) (MEASUREMENTS OVER 0-48 DAYS)

	Final weight (kg)	Feed gain	Digesta viscosity (cPs)	Relative feed cost/ kg gain (%)*
Maize control	2.45 b	1.86 b	2.5 d	100
20% wheat	2.47 b	1.88 b	3.5 c	101
20% wheat + AZ	2.46 b	1.84 bc	2.3 d	100
40% wheat	2.49 b	1.88 b	5.2 b	99
40% wheat + AZ	2.46 b	1.83 c	2.7 cd	99
60% wheat	2.50 ab	1.91 a	7.2 a	100
60% wheat + AZ	2.54 a	1.82 c	2.9 cd	98

a-d means in a row not sharing the some superscript are significantly different (P<0.01)
* Feed costs (including enzyme cost) are relative to maize control
Data from: Commercial Integrator, USA

Product	Target substrate (max. inclusion level)	AME uplift (%) MJ/kg	Max. AME value for cereal	CP/AA Uplift %(max)
1100	Barley (60%)	+ 10	12.76	+ 15
1200	Wheat	+ 6	13.60	+ 10
	Barley (30%)	+ 6	12.30	
1300	Wheat	+ 6	13.60	+ 10

Based on a number of trials adopting this experimental regime, Finnfeeds recommend the above up-lifts in wheat and barley specifications when using their new range of Avizyme products (the 1000 series).

Table 7

EXAMPLE FORMULATION USING ADJUSTMENTS TO ME AND 'AVAILABILITY' OF CRUDE PROTEIN/AMINO ACIDS IN WHEAT IN THE PRESENCE OF AVIZYME

Raw material	kg/tonne CONTROL DIET	kg/tonne + AVIZYME
Wheat*	556	598
Hipra Soya	300	300
Rapeseed meal	21	0
Fishmeal 67.5/9	21	20
Soyabean oil	60	39
DL-Methionine	2.0	1.9
Vitamins/minerals	40	40
Avizyme	0	1
Diet specification (%)		
Crude protein	23.3	22.9
Crude fat	7.6	5.6
ME Poultry*	13.0	13.0
Available lysine*	1.1	1.1
Available Met + Cys*	0.85	0.85
Relative formulation cost#	100	98

*assumes that in the presence of Avizyme the ME of wheat is increased by 6% and crude protein and amino acid 'availabiiity' by 10% (see above.)
#using UK prices as at beginning of September l994

Kev Words: Avizvme 1100. Avizvme 1200. Avizvme 1300. broiler. wheat. barlev. xvlanase. protease. beta-glucanase. uplift. ileal.