FEED ENZYMES IN POULTRY NUTRITION: RECENT FINDINGS

DAVID J. FARRELL AND ERNEST MARTIN

SUMMARY

Rapid progress has been made recently in feed enzyme technology. The question of heat stability is uncertain. Examination of the usual digestibility coefficients found for the major chemical components in formulated feeds suggests that there is potential to increase substantially their nutrient yield. A specific feed enzyme because of other enzyme contaminants may give unexpected results. Younger rather than older birds are more likely to benefit from many feed enzymes.

Results with hull-less oats gave improved growth and feed efficiency when a ß-glucanase was included in the diets of chickens and ducklings. This was due to an increase in fat digestibility and degradation of ß-glucans. As a consequence metabolizable energy (ME) also increased but these improvements were seen to a lesser extent in older birds. Other feed enzymes especially a phytase, but not a lipase were also beneficial in oat-based diets.

Improvements in phosphorus (P) utilization were substantial when a feed phytase was included in sorghum-soybean meal diets and fed to chickens and ducklings. P utilization improved by 18% on average in chickens and up to 53% on individual diets. ME was also improved. For ducklings overall P retention was improved by a mean of 29% with the highest individual increase of 45%. A slope-ratio assay using tibia ash as the criteron of response gave an availability of P in soybean meal of 58%. It was concluded that with a feed phytase virtually all of the P can come from vegetable ingredients. Rice bran in chicken and duckling diets also responded to phytase addition in growth rate and tibia ash. This improvement appeared to be due to the release of P from the bran. An enzyme cocktail specifically recommended for rice-bran based diets did not improve performance of ducklings. When used in higher dietary concentrations (1.5g/kg) there was a significant increase in feed intake and growth rate of broiler chickens (4-23d of age) on diets without and with 400g rice bran/kg. Lipase addition alone was not effective in improving performance on the former diet but it did improve performance on the latter.

Linseed meal (100g/kg feed) responded to a feed cellulase and a cocktail in growth rate and FCR. It was concluded that feed phytase gave the most consistent response in diets designed to test its efficacy. Other feed enzymes have shown variable and inconsistent respnses although ß-glucanase and some other feed enzymes are consistently successful in oat-based diets.

INTRODUCTION

Although exogenous feed enzymes have been available for about 40 years it is only recently that through advanced technology suitable preparations have become available to the feed industry and at a competitive price (Classen et al. 1991; Jacques 1990). The enzymes are normally of microbial origin and need to be effective over wide changes in pH along the digestive tract as well as elevated temperature during feed manufacturing. With the need to process the feed at high temperatures and sometimes under pressure to remove potential pathogens such as salmonella, the heat-stability of feed enzymes

Department of Biochemistry, Microbiology and Nutrition, University of New England, Armidale, N.S.W. 2351

becomes increasingly difficult to maintain. Inclusion levels in diets is very low but level depends on their purity and hence potency. Feed enzymes must have an acceptable storage life in compounded feeds of at least 2 months and must release chemical compounds in sufficient amounts or inactivate growth inhibitors to be of benefit to the host animal.

Thus the objective of feed enzyme additions should be to target specific substrates. Sometimes these are not clearly identified and under these circumstances a mixture (cocktail) of enzymes is used. The successful release of a specific substrate may depend on a number of feed enzymes that attack different chemical bonds. They may augment enzymes already present in the intestinal tract of animals or target a feed component normally completely indigestible or perhaps only fermented in the hind gut of monogastric livestock. Feed enzymes are also effective in counteracting the adverse effects of anti-nutritional factors and the non-starch complex polysaccharides (NSP) especially the ß-glucans and pentosans (Annison 1990). These NSP can increase viscosity of gut contents which may reduce digestion and absorption of other nutrients in the digestive tract (Beford and Classes 1992; Classen and Campbell 1990; Choct 1991). Choct and Annison (1992) concluded that wheat pentosans elecit their anti nutrititive activity largely through increasing the viscosity of digesta.

If we examine the apparent digestibility of the major chemical components in formulated diets based on grains, we find that the apparent digestibility of the fat fraction is normally high and in the range 90-95%. There are exceptions. Rice bran oil is not as digestible in young chickens as in adult birds (31-43% vs. 94%) with a concomitant reduction in metabolizable energy (ME) (Warren and Farrell 1990). This has also been reported for lipid in oats (Farrell et al. 1991). Apparent protein digestibility is about 80% while digestibility of the carbohydrate fraction varies from 70-85% depending on its composition. Normally starch is highly digestible (>95%) in non ruminant animals. Thus in order to increase the nutrient release from a feedingstuff, the NSP normally found in the cell walls may give the greatest opportunity. For example ß-glucans are found in barley and oats at up to 6%. Rye may contain up to 10% of arabinoxylans, and wheat also contains variable amounts of pentosans (Choct and Annison 1990). Mollah (1993) has suggested that wheat pentosans are not the cause of low metabolizable energy wheat.

Recently Creswell (1993) demonstrated the beneficial effects of enzyme cocktails in broiler diets in South Australia. Diets with the enzyme mixture and containing wheat or barley were assigned a standard ME value of + 6% and + 10% respectively.

We have recently assayed a number of commercially-available enzymes for potency and have identified a number of contaminants (Table 1). It is apparent that the feed enzymes, ß-glucanase and phytase, have potential activity for other substrates. As a consequence their target substrate may be difficult to identify. Both cocktails have high enzyme activity for ß-glucans and phytic acid phosphorus (P).

Although the benefits of exogenous enzymes appear to have much greater potential in the young animal, their real economic benefit may be in the older animal. The diet of the very young animal is expensive but the amount consumed during this time is only about one-quarter to one third of the total consumption to slaughter weight.

Plant by-products are used widely in the intensive animal feed industry. They may vary in quality and composition and may contain substantial amounts of cell wall material and anti-nutritive factors. Use of exogenous enzymes may be justified to improve their nutritional value.

This paper reports on research into the use of feed enzymes in poultry diets undertaken at the University of New England.

Table 1 The potency of four commercially-available feed enzymes and their potential to target different substrates

	Alpha amylase (u/g)	ß- glucanase (u/g)	Carboxy-methyl cellulase (u/g)	Pentosanase (u/g)	Phytase (u/g)
Cocktail A	6.1	42.9	10.3	5.7	21.4
Cocktail B	82.1	35.7	1.7	3.2	41.3
ß-glucanase	0.9	30.9	14.2	14.1	8.3
Phytase	1.0	3.0	20.8	7.8	53.4

OATS

Oats contain up to 6% ß-glucans. This is a NSP which is not only enzymatically indigestible in monogastric animals but it can cause sticky droppings in poultry. This has a number of adverse effects. Litter moisture increases and therefore ammonia production. There is damage to the respiratory tract, feet and legs and breast blisters may occur. In layers, dirty eggs may be a problem (Classen and Campbell 1990) and insect pests will thrive on the wet excreta and unpleasant odours may arise.

Farrell et al. (1991) reported on investigations into new varieties of hull-less or naked oats (NO). In one experiment we examined a range of enzymes to determine how effective they may be in increasing the ME of a diet containing 85% NO when fed to chickens at three ages and to adult cockerels. The results are shown in Table 2.

Table 2 The effect of various feed enzymes and an enzyme cocktail on the ME (MJ/kg) of a diet containing 85% NO fed to groups (n=3) of chickens at three different ages and to adult cockerels

Age	NO	NO + ß-glucanase	NO + lipase	NO + phytase	NO + protease	NO + cocktail	LSD (P<0.05)
4-9d	13.9	14.4	14.0	15.0	14.8	14.8	0.40
11-15d	14.1	14.6	14.3	15.0	15.2	15.0	0.40
18-23d	14.5	14.8	14.7	15.2	15.2	15.3	0.29
Adult	14.5	14.6	14.4	15.1	14.7	15.0	0.48

Only lipase failed to increase ME compared to the control diet (NO) at any age. The most consistent response was with phytase and the cocktail which increased ME even in adult birds. Generally enzyme addition was less effective as birds aged. We have reported previously the improvement in ME with age of bird and addition of ß-glucanase in pelleted diets containing either 71% wheat or NO at 60 and 84% (Farrell et al. 1991). Fat digestibility of diets shown in Table 2 increased at 49d with the addition of all enzymes except lipase, and at 18-23d for phytase, protease and the cocktail. Adult birds gave no response to enzymes due to the very high fat digestibility measured on all diets (95-98%). Mean values (%,±SD) were 75(1.4), 84(1.3), 88(0.6) and 97(0.2) at 4-9d, 11-15d, 18-23d and in adult birds respectively.

In another experiment we grew groups of broiler chickens from 3 to 17 d of age on cold-pelleted diets with 71% wheat, or with 60 or 84% NO without an enzyme or with a ß-glucanase or a cocktail. The results shown in Fig. 1 demonstrate the improvement in growth rate and feed conversion ratio (FCR) with the addition of enzyme to NO diets. There was no significant response to the wheat-based diet.

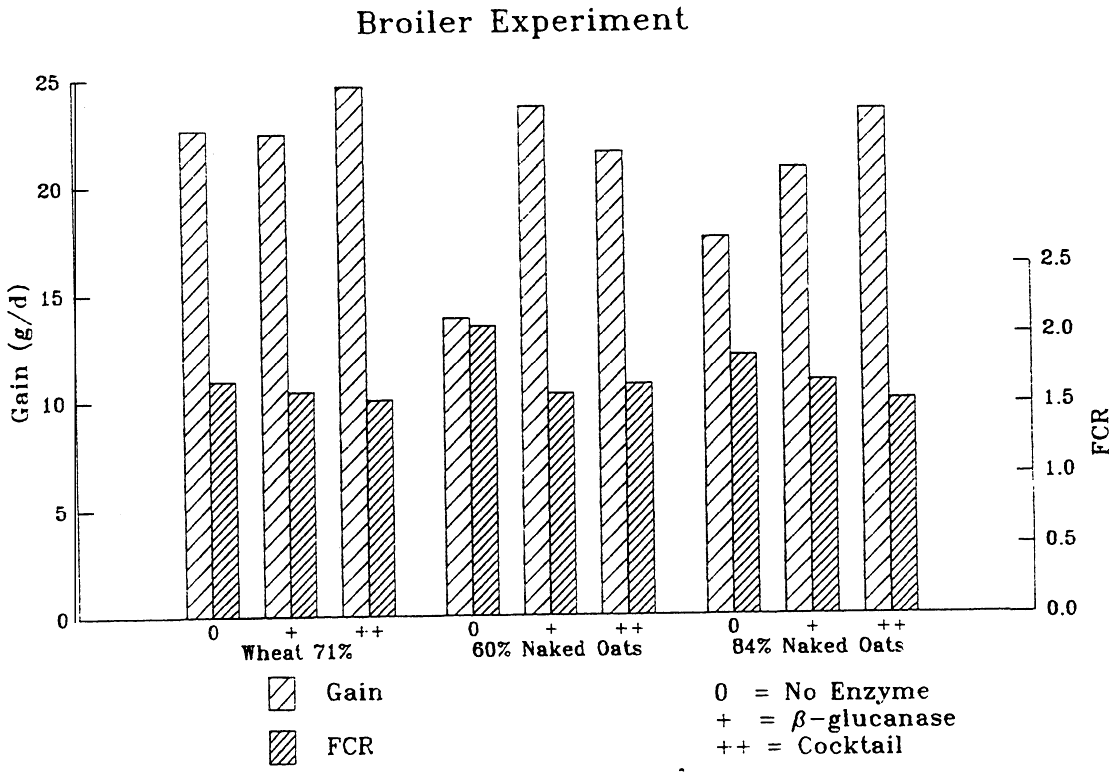

Figure 1. Effects of enzyme (o, + glucanase or ++ enzyme cocktail) addition to pelleted diets fed to male broilers grown from 3 to 17 days (LSD $P<0.05$ for growth = 2.61, FCR = 0.113).

In another experiment Takhar and Farrell (1992, unpublished data) fed growing meat-type ducks (10-21d of age) on diets with increasing amounts of NO (0-73%) with a ß-glucanase or phytase. The results are given in Table 3.

Table 3 Growth rate (g/d), feed intake (g/d) feed conversion ratio (FCR) of ducks (10-21d) offered diets without (-) or with ß-glucanase (+) or phytase (++) and the metabolizable energy (ME, MJ/kg) and fat digestibility (%) of the naked oat (NO) diets

NO %	0	20		40		60		73			LSD
		+	-	+	-	+	-	+	-	++	P<0.05
Gain	56.2	63.1	62.4	59.7	54.6	58.5	45.2	50.9	38.2	56.1	6.87
Feed intake	109	106	111	103	90	94	76	86	67	96	11.8
FCR	1.94	1.73	1.76	1.78	1.65	1.61	1.68	1.69	1.75	1.62	0.178
Fat dig	93.4	90.2	91.3	88.0	84.7	87.3	81.6	86.6	73.1	88.4	8.07
ME	14.8	15.4	15.4	15.2	14.9	15.7	15.1	16.0	15.6	16.2	0.75

Growth rate and feed intake on the diets declined with increasing NO inclusion above 20% (Table 3) and ß-glucanase became increasingly effective on diets with more than 20% NO. Phytase (++) addition to the diet with 73% NO was particularly effective as observed previously (Table 2). The control diet, based on wheat and sorghum, did not give as good a performance as the diet with 20% NO. Differences in overall ME due to enzyme treatment approached significance (P=0.089) and fat digestibility was significant (P<0.05) particularly on the diet with 73% NO.

Broz and Frigg (1986) reported improved growth rate (24%) and FCR (10%) of broiler chickens (8-25d) when a feed enzyme was added to diets with 66.5% oats. Further studies by Broz and Frigg (1990), using the enzyme complex (cocktail) produced by fermentation of Trichoderma viride, showed similar benefits when added to broiler chicken diets containing 66% oats.

SORGHUM - SOYBEAN MEAL DIETS

It is known that plant P is poorly available to non ruminant animals particularly poultry (Edwards 1991). We report here experiments with chickens and ducklings offered sorghum-soybean based diets with (+) or without (-) a microbial feed phytase (Natuphos, Gist-brocades, The Netherlands) included at 750 and 825 FTU/kg respectively.

The major ingredients in the diets were similar for the chicken and duckling experiments. Grain sorghum was held constant at 450 g/kg, soybean meal was 300 g/kg and replaced starch at 400 and 500 g/kg in diets 1-3. $CaHPO_4$ was included in diets 4 and 5 to give the same amount of total P as in diets2 and 3.

Diets l-3 contained a base level of 0.2 and 1 g of inorganic P (Pi) from $CaHPO_4$ for chickens and ducklings respectively. Diets were calculated to be isoenergetic and diet 1 was formulated to conform to nutrient specifications for meat-type ducklings and chickens; thus diets 2 and 3 had surplus protein and amino acids. Each diet was with (+) or without phytase (-). Ca : P ratios were held constant at 1.3:1. For each treatment there were 3 replicates of 10 chickens or 5 ducklings housed in individual electrically-heated brooders and grown to 18 d and 17 d of age respectively. Standard analytical methods were applied to feed, excreta and carcass mince (AOAC 1980). Excreta were collected in total for chickens and over 2-10 d for ducklings. For 10-17 d acid insoluble ash (AIA) was added as a marker to the duckling diet and its concentration in excreta was used to calculate dry matter digestibility of the diets.

The determined P content (g/kg) of chicken diets 1-5 was 4.1, 4.9, 5.3, 5.1 and 5.7 respectively. Results of the chicken experiment are given in Table 4.

There was a significant (P<0.05) positive overall effect of phytase on all parameters measured. Diet 5, which contained the highest addition of CaHP04, did not give a positive response in biological performance when enzyme was added to the diet. However P retention was significantly greater (P<0.05) on all diets with enzyme except diet 3 using carcass I? Tibia ash (%) was not increased on diet 5 but other parameters did improve. This suggests that P in diet 5 was close to the optimum level. Except for diet 1, ME of diets increased with enzyme addition. Overall, P retention increased by 18% when determined in feed and excreta or by carcass analysis. Diet 2 yielded an increase of 53%. Measured phytic acid P in the experimental diets was 62%, 60% and 57% of the plant P in diets, 1, 2 and 3 respectively.

Table 4 Effect of diets with (+) and without (-) phytase on biological performance of chickens (1-18d), feed utilisation, phosphorous retention and tibia ash

Diet	Gain (g/d)	Feed intake (g/d)	ME_n (MJ/kg)	Phosphorus retention (mg/d)	(%)[a]	(%)[b]	Tibia ash (g)	(%)
1 -	17.2	26.8	13.0	70	55.7	46.1	0.29	42.3
+	19.6	30.2	13.0	96	67.4	52.0	0.41	48.0
2 -	18.2	27.1	12.5	85	54.7	40.2	0.34	43.1
+	23.1	31.1	13.0	125	70.7	61.7	0.50	48.4
3 -	22.8	30.6	12.4	107	55.6	56.6	0.57	45.7
+	24.4	31.8	13.0	124	62.7	54.4	0.59	49.0
4 -	18.3	28.1	13.1	100	60.1	44.8	0.41	47.4
+	20.6	30.6	13.3	125	70.4	54.0	0.46	50.0
5 -	19.7	30.4	13.0	114	57.1	46.0	0.44	49.1
+	19.7	30.6	13.2	130	63.8	52.2	0.49	49.9
SEM	0.48	0.052	0.02	3.1	1.24	2.37	0.044	0.02
Enz- -	19.2	28.6	12.8	95	56.6	46.7	0.39	45.5
yme +	21.5*	30.9*	13.1*	120*	67.0*	54.9*	0.49*	49.1*

[a]Measured in feed and excreta and [b]wet carcass
*P<0.05

A preliminary experiment showed that for ducklings it was necessary to increase Pi to 1g/kg diet in order to avoid "rubbery beaks" and leg deformities. For ducklings, enzyme addition increased (P<0.05) feed intake and growth rate on diets 1-3 but not diets 4 and 5 (Table 5). FCR was unaffected by enzyme addition. Tibia ash gave a significant response to phytase on diets l-4. Phosphorus retention was improved overall by 29% with phytase addition at 2-10 d using total excreta collection. On d 10-17, overall P retention increased (P<0.01) by 9% from 53.1 to 57.6% as a result of added enzyme using AIS. Differences at 10-17 d between + and - enzyme were fewer than over 2-10 d, this may have been due to age of bird. Greatest improvement was on diet 3 (45%) on d 10-17 and diet 1 (16%) on d 10-17. At both ages dry mater digestibility was improved (P<0.01) with enzyme addition.

Table 5 Effects of diets with (+) and without (-) a feed phytase on performance parameters in ducklings (2-1 7 d)

Diet	1		2		3		4		5		LSD
	+	-	+	-	+	-	+	-	+	-	P=0.05
Feed (g/d)	88	76	86	80	86	80	85	86	86	87	2.7
Gain (g/d)	50	44	51	48	50	47	50	49	50	51	2.9
Tibia ash (g)	1.0	0.7	1.1	0.9	1.2	1.0	1.1	1.0	1.1	1.2	0.13
(%)	45	36	46	39	47	43	46	43	46	46	2.14
P ret (%)											
2-10 d	53	39	48	34	47	32	56	43	54	50	5.6
10-17 d	64	55	59	53	53	48	58	55	54	53	5.7

Shown in Fig. 2 is the effect on tibia ash of increasing dietary P by adding soybean meal to diets 1-3 and $CaHPO_4$ to diets 4 and 5. The slopes of the linear regression equations were used to calculate P availability in soybean meal assuming that P in CaHP04 is completely available which is unlikely; the ratio was 0.58, or 58% available P. The addition of phytase to diets 3 and 4 gave virtually the same tibia ash weight as did diets 4 and 5 with added $CaHPO_4$. This suggests that most of the P in duck diets can come from plant sources provided a phytase is added.

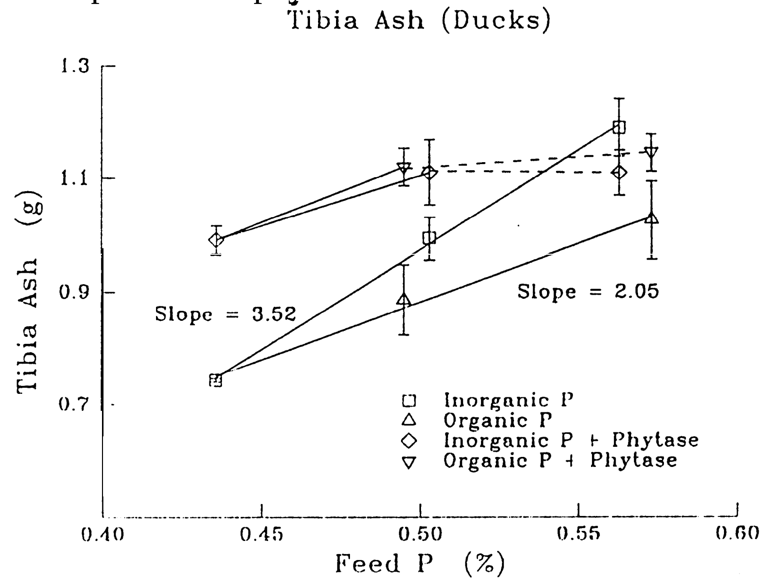

Figure 2. **The increase in tibia ash in ducklings on diets with different amounts of phosphorus provided by soybean meal or $CaHPO_4$ with and without phytase.**

The results of these experiments confirm the beneficial effects of adding phytase to diets of chickens (Simons et al. 1990, 1992) and ducklings at least to about 3 weeks of age. For chickens plant sources of P can be used with only very small amounts of Pi provided the diet contains about 5.3 g total P/kg. For ducklings the situation is similar except that the base level of Pi is about 1g/kg diet. Not only will there be considerable savings on expensive P supplements to diets but P in excreta will be reduced substantially thereby reducing pollution of the waterways.

RICE BRAN

Rice bran is used widely as a poultry supplement in South-East Asia. However it can contain up to 4.3% phytate (Warren and Farrell 1990). The purpose of this study was to include rice bran in diets of ducks grown from 19 - 40 d of age with and without a microbial phytase. The diets, formulated to duck nutrient specifications, contained only plant ingredients based largely on grain sorghum and soybean meal. All diets contained 1g per kg Pi from $CaHPO_4$ and 6 g of Ca per kg. Rice bran was substituted for grain sorghum at 300 and 600 g/kg diet. These diets were equal in nitrogen and ME and were with (+) or without (-) microbial phytase (Gist-brocades, The Netherlands) at 1000 FTU/kg. Thus there were 6 diets x 3 replicates x 5 ducklings per treatment held in suitable cages and-managed as described previously (Farrell 1990). The results are given in Table 6.

Calculated total P and available P (assuming 30% of phytic acid P) in g/kg were 5.0, 8.5, 12.0 and 1.2, 2.2 and 3.3 of diets with 0,300 and 600 g rice bran/kg diet respectively.

Table 6 Performance and bone ash measurements of groups of 5 ducks grown from 19 to 40 d of age on diets containing rice bran with (+) or without (-) phytase

	Rice bran (g/kg)						LSD
	0		300		600		(P=0.05)
Enzyme	+	-	+	-	+	-	
Gain (g/d)	85.5	78.3	77.8	74.4	71.8	67.3	2.71
Food intake (g/d)	211	212	194	193	178	178.8	5.96
FCR	2.47	2.70	2.49	2.60	2.48	2.64	0.111
Tibia ash (g)	2.84	2.82	2.61	2.39	2.27	2.10	0.16
(%)	53.4	52.0	52.2	51.6	50.5	50.3	0.97

Rice bran addition without enzyme decreased ($P<0.05$) growth rate and food intake but not FCR. While weight of tibia ash declined ($P<0.05$). Overall, enzyme addition improved performance ($P<0.05$) except for food intake. On all diets growth rate improved with enzyme addition. Bone ash (% dry and fat-free tibia) improved significantly only on the diet with no rice bran. Values for tibia ash (g and %) on this diet with enzyme were always higher ($P<0.05$) than on the two diets with rice bran. Enzyme addition may have been inadequate to make the high phytic acid more available. It is concluded that phytase addition can increase utilization of rice bran by finisher ducks by making some of the phytic acid P more available. However phytase may also increase the availability of the other dietary nutrients.

We added 1000 FTU of pytase to duckling diets with all plant ingredients and containing 0, 20 or 40% rice bran. The diets were adequate (0.3%) or inadequate (0.1%) in Pi included as CaHP04. The results shown in Table 7 indicate that phytase was effective for feed intake and growth rate on all diets except that with 20% rice bran and 0.3% P when ducklings were grown from 2 to 19 d of age. The best response was seen on the basal diet without rice bran and 0.1% Pi.

Table 7 The performance of ducklings grown from 2 to 19 days on all-vegetable diets with 0, 20 or 40% rice bran with either 0.1 or 0.3% inorganic phosphorus (Pi) with (+) and without (-) a phytase enzyme (E)

Rice bran (%)	P (%)	E	Gain (g/d)	Feed (g/d)	FCR	Tibia ash (g)	Tibia ash (%)	Dig (%) (10-19d) P	Dig (%) (10-19d) Ca
0	0.1	-	44.2	71.7	1.62	0.71	36.7	38.80	32.9
0	0.1	+	52.6	88.1	1.67	0.98	43.9	45.40	38.2
20	0.1	-	50.2	84.7	1.69	1.00	42.5	29.10	23.0
20	0.1	+	53.1	93.5	1.76	1.23	47.4	37.40	35.4
20	0.3	-	53.5	90.1	1.68	1.15	46.5	31.60	40.7
20	0.3	+	53.6	90.2	1.68	1.21	46.1	34.90	44.2
40	0.1	-	49.0	88.7	1.81	1.01	44.4	26.50	41.1
40	0.1	+	51.6	91.9	1.78	1.00	45.3	29.20	41.6
40	0.3	-	47.3	83.4	1.76	1.02	44.7	30.30	45.0
40	0.3	+	50.0	87.0	1.74	1.07	45.3	30.40	43.8
LSD (P=0.05)			2.26	3.62	0.057	0.176	2.48	4.60	3.88

There was a phosphorus x diet interaction (P<0.01) for feed intake and growth rate. On the diet with 20% rice bran 0.3% Pi addition increased growth compared to 0.1% Pi, but it had the reverse effect in diets with 40% rice bran. For tibia ash (%) there was a phosphorus x enzyme interaction (P=0.051). The enzyme gave a response only in diets with 0.1% Pi. This suggests that Pi was the limiting factor only in the diets with 0.1% I? The performance parameters suggested that there was possibly a small mineral imbalance in the diets with 0.3% Pi and 40% rice bran. It can be concluded that phytase is effective in releasing P from rice bran. As little as 0.1% Pi as CaHP04 is adequate to maximise performance and bone parameters provided a phytase is added. Interestingly when phytase was added to diets with 40% rice bran there was a significant improvement in growth rate at both Pi inclusions.

Phytase significantly (P<0.05) increased the apparent digestibility of Ca and P but mainly on diets with 0 and 20% rice bran with 0.1% Pi (Table 7). Clearly phytate has an adverse effect on calcium uptake. This was not seen clearly on some other trace elements examined (Cu, Zn, Mg, Fe and Mn).

Although phytase has been shown to be effective in releasing P from rice bran enzymes that target other components have not been tested. We have examined in duck diets an experimental feed enzyme cocktail designed for diets with high levels office bran. The results are given in Table 8.

Table 8 The inclusion of an enzyme cocktail in rice bran based diets when fed to finisher ducks from 19-35 days of age

	Rice bran (%)						
	0		30		60		LSD
Enzyme	+	-	+	-	+	-	(P=0.05)
Growth rate (g/d)	91.2	89.9	97.8	95.0	88.8	88.5	7.54
Feed intake (g/d)	217	217	222	215	214	216	17.35
FCR	2.38	2.41	2.27	2.27	2.41	2.44	0.178

Enzyme addition did not improve any parameter examined although diets with 30% bran with enzyme had significantly improved growth rate and FCR compared to diets with 60% bran.

The same enzyme cocktail as that unsuccessful with ducks (Table 8) and previously with chickens at 1g/kg feed was included at 1.5g/kg in a second experiment in diets with and without rice bran. A lipase was also investigated in these two diets.

Table 9 The effect of a feed lipase and an enzyme cocktail on performance of male broiler chickens grown from 4 to 23 days of age on a diet without (-) or with (+) 400 g rice bran/kg.

Enzyme	Growth rate (g/d)		Feed intake (g/d)		FCR	
	-	+	-	+	-	+
0	20.1	18.5	35.4	31.7	1.76	1.72
Lipase (0.23g/kg)	24.0	18.1	38.9	31.3	1.62	1.75
Lipase (0.45g/kg)	20.8	18.1	36.7	31.2	1.77	1.80
Cocktail (1.5g/kg)	22.5	20.2	37.4	34.0	1.66	1.68
Lipase (0.45g/kg) + cocktail (1.5g/kg)	21.6	20.0	37.4	32.5	1.73	1.65
LSD (P=0.05)	1.68		2.56		0.13	

The improvement ($P<0.05$) in growth rate and feed intake when a liquid lipase at 0.23 g/kg was added to a diet based largely on sorghum and soybean meal was not seen when rice bran replaced sorghum (Table 9), nor at 0.45g/kg inclusion. When an enzyme cocktail was included in both diets, feed intake and growth rate increased significantly. Addition of a lipase (0.45g/kg) with the cocktail improved ($P<0.05$) growth rate on both diets but not feed intake on the diet with rice bran. Rice bran is high in neutral detergent fibre and it appears that enzymatic degradation of some of the fibrous components had occurred rendering them available to the birds. Throughout, FCR was not affected significantly ($P>0.05$). Although rice bran oil has a low apparent digestibility in young chicks the feed lipase did not improve performance.

LINSEED AND LINOLA MEAL

These are two very similar meals and rarely used in the intensive poultry industry. Linola meal is a cultivar of linseed meal selected for low linolenic acid. Both contain high amounts of NSP and mucilage which are poorly utilized by poultry as well as other anti-nutritional factors. Farrell and Green (1991, 1992 unpublished data) have investigated these meals in poultry diets with high variable results. The addition of enzymes has sometimes given responses in broiler and layer diets. We investigated the use of a cellulase (1.25g/kg) and an enzyme cocktail (1.0g/kg) in broiler-finisher diets containing 10% linseed or linola meal. The results are given in Table 10.

Table 10 Response of broilers (22-46d) on diets with 10% linseed or linola meal without (0) or with an enzyme cocktail (A) or a cellulase (C)

	Linseed			Linola			LSD
	O	A	C	0	A	C	($P=0.05$)
Feed intake (g/d)	126	116	119	144	147	129	13.4
Growth rate (g/d)	43.4	47.0	54.0	42.0	45.7	48.0	9.00
FCR	2.90	2.46	2.21	3.51	3.13	2.70	0.54

Enzyme addition significantly (($P<0.05$) improved growth rate and FCR and decreased ($P=0.08$) feed intake. The cellulase was more effective than the enzyme cocktail and was more effective in the linseed than the Linola meal diets. This we have seen previously.

CONCLUSIONS

Feed enzymes have potential in improving the nutritional worth of a range of feedingstuffs (Hesselman 1989). Young birds generally respond to feed enzymes to a greater extent than older birds. In the past this may be due to poor enzyme development and low gut fermentation in the young bird. Beta glucanase is generally effective when added to oat-based diets. The efficacy of some feed enzymes may be uncertain as illustrated by the inability of a feed lipase to enhance fat digestibility in a diet high in NO particularly as other feed enzymes were effective.

Feed phytase appears to give a consistent response in releasing phytic acid P in significant amounts from plant-based diets (Simons et al. 1992). Not only will this reduce the dietary inclusion of P but also its concentration in excreta. For both ducks and chickens the majority of their P requirements can be met by plant P provided a feed phytase is included. Phytase was particularly effective in releasing P from rice bran which is rich in phytic acid I? Attempts to improve the nutritive value of the NSP fraction of rice bran with feed enzyme additions have to date been only partially successful. Similar attempts with other feed ingredients have generally yielded inconsistent and variable results.

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