

Effects of dietary phytase supplementation on performance of broilers fed on low phosphorous and low protein barley-based diets

M. TORKI^{*1}, E. HAGHVERDILOO¹

¹Department of Animal and Poultry Science, Agricultural Faculty, Razi University, Imam Avenue, Postal Box: 1158, Postal Code: 67155, Kermanshah, Iran.

^{*1}Corresponding author: torki@sci.razi.ac.ir

In the purpose to reducing excretion of nitrogen and phosphorous without the influence of growth performance in broiler chicks, a feeding trial were conducted. Two hundred and forty day-old Ross chicks of both sexes were housed in 40 floor pens and allocated to ten replicates of four iso-caloric corn-barley-soybean based diets. Treatments were based on: two different concentrations of crude protein (CP) and non-phytate P (NPP) with or without phytase (Ronozyme[®]). Decreasing dietary CP or NPP negatively influenced BW. The adverse effects were not overcome by the addition of phytase. There were no significant differences in FI between C and L diets during 0 to 21 and 43 to 49 days of age. In addition, there were no significant differences in FI between C and LP diets during 43 to 49 days of age. Decreasing dietary CP or NPP had no negative effects on FCR during 0 to 21 days of age. However, phytase supplementation did not improve FCR of birds fed on low protein and low P diets. In general, dietary inclusion of phytase could partially ameliorate the adverse effects of decreasing P on FI or FCR, but not in case of low CP and NPP diets.

Key words: phytase; low non-phytate phosphorus; low protein; barley; broiler

Introduction

Lowering crude protein is effective in decreasing N excretion in poultry production (Ferguson *et al.*, 1998; Blair *et al.*, 1999). Excess dietary protein also increases heat production and water consumption which increases moisture content of litter (Alleman and Leclercq, 1997). Reducing CP diets by 2% in starter period did not affect body weight gain (Parr and Summer, 1991; Moran and Stiborn, 1996). However, some other researchers showed that feeding low protein diets to broilers decreased growth performance (Ferguson *et al.*, 1998; Jensen, 1991).

Phytic acid is an ester of cyclic alcohol inositol with 6 phosphates. Its salt, phytate, is the major forms P (Reddy *et al.*, 1982). Phytin is a collective term for this mixed salt (Odani *et al.*, 1997) and it constitutes up to 3% of many of the oilseeds and cereals used in animal feeds. The inability of poultry to utilize phytate P, due to lack of endogenous phytase, results in the addition of inorganic feed P to poultry diets in order to meet the P requirements of poultry. However, P is the third most expensive nutrient in poultry diets after energy and protein (Biehl *et al.*, 1998), and phytate P passed out in animal excreta leading to accumulation of P in soils and subsequently its entry into surface and ground waters and sparking off major environmental concerns (Kornegay and Harper, 1997).

Phytase (myo-inositol-hexakisphosphohydrolase) degrades phytate to yield inositol monophosphate and orthophosphate via inositol penta to monophosphates as intermediary products. It has been well documented that phytase improves P utilization in poultry (Roberson and Edwards, 1994; Denbow *et al.*, 1995; Boling-Frankenbach *et al.*, 2001; Onyango, *et al.*, 2005; Ravindran, *et al.*, 2006). Further studies have suggested that microbial phytase can have beneficial effects on amino acid digestibility in poultry (Biehl and Baker, 1997; Sebastian *et al.*, 1997; Ravindran *et al.*, 1999).

Although the benefits of the addition of exogenous phytase to wheat, rye, barley, oilseeds and lupines have well documented, whether the benefits of phytase on low protein-low P diets will also be demonstrable in barley included diets is not as evident. The present experiment was conducted in order to investigate the effects of addition of phytase to corn-barley based diets on performance of growing broiler chicks.

Materials and methods

Two hundred and forty day-old Ross chicks of both sexes were housed in 40 floor pens and allocated to ten replicates of four iso-caloric corn-barley-soybean based diets. The control diets (C) contained 20.13, 17.50, and 15.75 % CP for 0 to 21, 22 to 42, and 43 to 49 days of age, respectively. In the second diets (L), CP was reduced to 18.11, 15.75, and 14.18 for three phases and crystalline methionine was added to be 100% of NRC-recommended requirements. In the third diets (LP), NPP were reduced to 60% of requirements (0.24, 0.18, and 0.17% for three phases) and commercial phytase (Ronozyme[®]) was added. In the fourth diets (LE), both CP and NPP were reduced to the similar levels as second and third diets, respectively and phytase was added. Chicks were given free access to diets and body weight (BW), feed intake (FI) and mortality recorded to calculate feed conversion ratio (FCR). Data were analyzed using the GLM procedures of SAS (SAS Institute, 1996). Means were separated for significance by Duncan's multiple range test at significance level of $P < 0.05$ or as indicated.

Table 1. Composition (g/kg) of experimental diets

Ingredients	Starter diets				Grower diets				Finisher diets			
	C	L	LP	LE	C	L	LP	LE	C	L	LP	LE
Corn	188.9	217.9	187.7	216.6	143.2	168.3	142.2	167.3	100.9	123.4	100.1	122.6
Barley	400.0	400.0	400.0	400.0	550.0	550.0	550.0	550.0	650.0	650.0	650.0	650.0
Soybean meal	313.1	249.0	310.8	246.7	228.3	172.9	226.5	171.1	174.3	124.2	172.9	122.8
Wheat bran	10.5	44.8	17.7	51.9	-	29.6	5.6	35.2	0.007	26.8	4.3	3.11
Sunflower oil	50.0	50.0	50.0	50.0	45.0	45.0	45.0	45.0	45.4	45.4	45.4	45.4
DCP	11.9	12.3	3.4	3.9	7.4	7.8	0.8	1.2	5.1	5.4	-	0.3
Oyster shell	13.2	13.3	18.2	18.3	14.2	14.2	18.0	18.1	13.5	13.6	16.5	16.6
Sodium chloride	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Mineral premix	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Vitamin premix	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lysin-HCl	0.9	1.0	0.9	1.0	1.2	1.2	1.2	1.3	0.4	0.5	0.4	0.5
DL-Met	1.4	1.7	1.4	1.7	0.7	0.9	0.7	0.9	0.4	0.6	0.4	0.6
Calculated analysis												
ME (Kcal/kg)	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
Crude protein	201.3	181.1	201.3	181.1	175.0	157.5	175.0	157.5	157.5	141.8	157.5	141.8
Calcium	8.75	8.75	8.75	8.75	7.88	7.88	7.88	7.88	7.00	7.00	7.00	7.00
Non-phytate P	3.94	3.94	2.36	2.36	3.06	3.06	1.84	1.84	2.63	2.63	1.68	1.68
Arginine	12.74	11.18	12.73	11.17	10.57	9.23	10.57	9.23	9.23	8.02	9.23	8.02
Lysine	11.21	9.84	11.20	9.84	9.61	8.39	9.61	8.39	7.85	6.82	7.85	6.82
Methionine	4.38	4.38	4.38	4.38	3.33	3.33	3.33	3.33	2.80	2.80	2.80	2.80

Results and discussion

Growth rate, FI and FCR for broiler chicks fed on experimental diets with and without exogenous phytase supplementation were shown in table 2. Decreasing CP and NPP decreased BWG during 0-21 and 22-42 days of age, and phytase supplementation did not ameliorate the adverse effects. However, the adverse effects of lowering NPP were overcome by phytase inclusion during 43 to 49 days of age, so there was no significant difference in BWG between C and LP diets. Juanpere *et al.* (2004) also reported that the addition of exogenous phytase to the P-deficient diets improved animal performance to levels comparable to chicks fed positive control diets. It is reported that the utilization of not only phytate P but also CP were improved by supplementation of phytase (Yonemochi *et al.*, 2000). In this study the same efficiency of phytase was not observed, which might indicate that the level of decreasing of CP and NPP in diet LE was high or the capability of phytase in overcoming this kind of adverse effects was not high enough. Reducing both NPP and CP decreased the FI of birds and phytase supplementation was not effective in overcoming the adverse effects. There was no significant difference in FI between diets C and L during 0-21 and 43-49 days of age. Phytase inclusion improved FI of birds fed on diet LP during 43 to 49 days of age. There was no statistically significant difference in FCR between diets C and L. Phytase supplementation partially improved the FCR of birds fed on low NPP diets in starting and finishing periods. Decreasing both CP and NPP increased FCR and phytase supplementation did not improve it.

Table 2. Growth rate (gain/bird/d), feed intake (feed/bird/d) and feed conversion ratio (g: g) for broiler chicks fed on corn-barley-soybean based diets with and without phytase supplementation

		Body weight gain (g/chick/day)			
Diet	Enzyme	0-21	22-42	43-49	0-49
Control (C)	No enzyme	30.05±0.85 ^a	69.08±3.38 ^a	73.62±8.09 ^a	54.50±1.59 ^a
Low Protein (L)	No enzyme	27.51±1.29 ^b	61.04±3.69 ^b	63.60±8.14 ^b	47.69±3.57 ^b
Low P (LP)	Phytase	27.15±2.68 ^b	58.70±5.1 ^b	71.93±8.79 ^a	45.86±6.05 ^b
Low Protein-low P	Phytase	23.19±1.54 ^c	53.06±3.50 ^c	52.16±7.43 ^c	40.42±3.99 ^c
MSE		0.77	1.78	3.63	1.84
		Feed intake (g/chick/day)			
Diet	Enzyme	0-21	22-42	43-49	0-49
Control (C)	No enzyme	47.72±1.30 ^a	143.5±6.79 ^a	206.53±16.07 ^a	112.43±4.95 ^a
Low Protein (L)	No enzyme	47.33±1.57 ^a	133.25±5.55 ^b	191.93±12.14 ^a	104.09±5.55 ^b
Low P (LP)	Phytase	44.82±1.81 ^b	134.76±10.72 ^b	192.94±23.78 ^a	98.87±8.61 ^{bc}
Low Protein-low P	Phytase	44.99±4.63 ^b	122.43±14.86 ^c	171.07±17.49 ^b	94.39±6.64 ^c
MSE		1.20	4.54	7.99	2.95
		Feed conversion ratio (g: g)			
Diet	Enzyme	0-21	22-42	43-49	0-49
Control (C)	No enzyme	1.59±0.07 ^b	2.08±0.09 ^b	2.82±0.28 ^{bc}	2.06±0.06 ^b
Low Protein (L)	No enzyme	1.72±0.07 ^b	2.19±0.09 ^{ab}	3.05±0.27 ^{ab}	2.19±0.07 ^b
Low P (LP)	Phytase	1.67±0.18 ^b	2.31±0.29 ^a	2.72±0.44 ^c	2.17±0.14 ^b
Low Protein-low P	Phytase	1.95±0.27 ^a	2.31±0.30 ^a	3.30±0.24 ^a	2.35±0.23 ^a
Pooled MSE		0.07	0.09	0.14	0.06

References

- ALLEMAN, F. and LECLERCQ, B. (1997) Effect of dietary protein and environmental temperature on growth performance and water consumption of broiler chickens. *British Poultry Science* **38**: 607-610.
- BIEHL, R.R. and BAKER, D.H. (1997) Microbial phytase improves amino acid utilization in young chicks fed diets based on soybean meal but not diets based on peanut meal. *Poultry Science* **76**: 355-360.
- BIEHL, R.R., BAKER, D.H. and DELUCA, H.F. (1998) Activity of various hydroxylated vitamin D3 analogs for improving phosphorus utilisation in chicks receiving diets adequate in vitamin D3. *British Poultry Science* **39**: 408-412.
- BLAIR, R., JACCOP, J.P., IBRAHIM, S. and WANG, P. (1999) A quantitative assessment of reduced protein diets and supplements to improve nitrogen utilization. *Applied Poultry Research* **8**: 25-47.
- BOLING-FRANKENBACH, S.D., PETER, C.M., DOUGLAS, M.W., SNOW, J.L., PARSONS, C.M. and BAKER, D.H. (2001) Efficacy of phytase for increasing protein efficiency ratio values of feed ingredients. *Poultry Science* **80**: 1578-1584.
- DENBOW, D.M., RAVINDRAN, V., KORNEGAY, E.T., YI, Z. and HULET, R.M. (1995) Improving phosphorus availability in soybean meal for broilers by supplemental phytase. *Poultry Science* **74**: 1831-1842.
- FERGUSON, N.S., GATES, R.S., TARABA, J.I., CANTOR, R.H., PESCATOR, A.J., FORD, M.J. and BURNHAM, D. J. (1998) The effect of dietary crude protein on growth, ammonia concentration and litter composition of broiler. *Poultry Science* **71**: 1481-1487.
- JENSEN, L.S. (1991) Broiler performance as affected by intact protein versus synthetic amino acid. Page: 83-89. in: *Proceeding Georgia Nutrition Conference*. Atlanta, GA.
- JUANPERE, J., PÉREZ-VENDRELL, A.M., AND BRUFAU, J. (2004) Effects of microbial phytase on broilers fed barley-based diets in the presence or not of endogenous phytase. *Animal Feed Science and Technology* **115**: 265-279.
- KORNEGAY, E.T. and HARPER, A.F. (1997) Environmental nutrition: nutritional management strategies to reduce nutrient excretion in swine. *Profitable Animal Science* **13**: 99-111.
- MORAN, E.T.Jr. and STILBORN, B. (1996) Effect of glutamic acid on broiler given sub marginal crude protein with adequate essential amino acids using feeds high and low in potassium. *Poultry Science* **75**: 120-129.
- ODANI, A., TAKAMIDO, R., and YAMAGUCHI, O. (1997) Phytate, an environmental phosphate from grain source. Metal complex formation and degradation by phytase. *Journal of Inorganic Biochemistry* **67**: 378.
- ONYANGO, E.M., BEDFORD, M.R. and ADEOLA, O. (2005) Efficacy of an evolved *Escherichia coli* phytase in diets of broiler chicks. *Poultry Science* **84**: 248-255.
- PARR, J.F. and SUMMER, J.D. (1991) The effect of minimizing amino acid excess in broiler diets. *Poultry Science* **70**: 1540-1549.
- ROBERSON, K.D. and EDWARDS, H.M. (1994) Effects of 1, 25-dihydroxycholecalciferol and phytase on zinc utilization in broiler chicks. *Poultry Science* **73**: 1312-1326.
- RAVINDRAN, V., MOREL, P.C.H., PARTRIDGE, G.G., HRUBY, M. and SANDS, J.S. (2006) Influence of an *Escherichia coli*-derived phytase on nutrients utilization in broiler starters fed diets containing varying concentrations of phytic acid. *Poultry Science* **85**: 82-89.
- RAVINDRAN, V., CABAUG, S., RAVINDRAN, G. and BRYDEN, W.L. (1999) Influence of microbial phytase on apparent ileal amino acid digestibility of feedstuffs for broilers. *Poultry Science* **78**: 699-706.
- REDDY, N.R., SATHE, S.K. and SALUNKHE, D.K. (1982) Phytates in legumes and cereals. *Advances in Food Science* **28**: 1-92.
- SEBASTIAN, S., TOUCHOBURN, S.P., CHAVEZ, E.R. and LAGUE, P.C. (1997) Apparent digestibility of protein and amino acids in broiler chickens fed corn-soybean diet supplemented with microbial phytase. *Poultry Science* **76**: 1760-1769.
- YONEMOCHI, C., TAKAGI, H., HANAZUMI, M., and OKADA, T. (2000) Improvement phytate phosphorous availability by microbial phytase. *Japanese Poultry Science* **35**: 154-161.