

Calcium level modulate phytate conversion degree and type of phytase A effects on production traits and egg shell quality in laying hens

K. Żyła^{1*}, M. Mika¹, J. Koreleski², S. Świątkiewicz², ¹Krakow Agricultural University, Department of Food Biotechnology, Al. 29-Listopada 46, 31-425 Krakow, Poland

²National Research Institute of Animal Production, Department of Animal Nutrition and Feed Science in Aleksandrowice, 32-083 Balice, Poland. E-mail: kzyla@ar.krakow.pl

Abstract

At low level of dietary calcium and phosphorus (2.6 and 0.36%, respectively), phytate conversion degree raised by the addition of phytase B to feeds that had already been supplemented with 3- or 6- phytase A, modulated production traits and egg shell quality of Hy Line Brown laying hens fed maize-soybean meal from week 40 to 54. Feed consumption, laying rate (average daily egg production), mean egg weight and shell breaking strength depended on the type of phytase A added to feeds only at low level of phytate conversion degree. At higher level of calcium (3.6 %) phytate conversion degree did not exert any effect on the parameters studied and the efficacy of 3- and 6-phytases A was similar. A hypothesis that myo-inositol phosphate intermediates produced by 6-phytase A modulate calcium metabolism by a highly specific mechanism that prevents metabolites of 3-phytase A to play a similar role is substantially evidenced by the experiment.

Introduction

The theory of enzymic breakdown of phytate compounds distinguishes between liberation of phytate molecules from complexes with other tissue components and enzymic cleavage of phosphate residues on the myo-inositol ring. These two distinct phenomena, defined by dephosphorylation level and phytate conversion degree (CD) are affected by phytases A and phytase B, respectively (Żyła et al., 2004). Phytate molecule should be perceived not only as a chelating agent, whose antinutritional properties may be reduced by phytase A, but also as a source of myo-inositol and lower phosphates of myo-inositol supplied by the common action of phytases A and B. The objectives of the current study were to determine the efficacy of commercial 3- and 6-phytases A at different conversion degree in laying hens fed phosphorus deficient maize-soybean meal diets containing either 2.6 or 3.6% Ca.

Materials and Methods

One hundred eight Hy Line Brown laying hens were placed in wired cages and divided into 12 dietary treatments with 3 cage replicates of 3 hens each. Experimental dietary treatments were fed from week 40 to 54. Diets and water were provided *ad libitum*. The basal Ca and P deficient diet (2.8% Ca and 0.36% total P) was composed of (g/kg) maize – 681, soybean meal - 240, limestone – 70, NaCl – 3, vitamin and mineral premix –5, and DL- methionine -1 was supplemented with phytase B at 50000 PHFU/kg and two commercial phytases A (3- or 6- phytase A) at 250 FTU/kg or unsupplemented. Six identical diets were prepared with Ca content at 3.6%. Experimental design was 2x3x2 factorial with 2 levels of calcium, 3 levels of phytase A (none, 3-phytase, 6-phytase) and two levels (low, high) of phytate conversion degree. Feed consumption, feed per egg, egg production, a mean egg weight, laying rate, shell breaking strength and shell thickness were measured. Data were analyzed by the Statgraphics Plus for Windows v.5.1 statistical software. Mean differences were determined using Duncan test. Statistical significance was accepted at $P < 0.05$.

Results and Discussion

At the low level of calcium, significant treatment effects were observed for feed consumption ($P < 0.01$), egg weight ($P < 0.1$), laying rate (average daily egg production; $P < 0.05$) and for shell breaking strength ($P < 0.01$) but egg production and feed per egg conversion ratio did not depend on dietary supplements (Table 1). Feed consumption was affected by phytase addition ($P < 0.05$) and there was a significant interaction between phytase and CD ($P < 0.01$). To the contrary, egg weight depend on CD ($P < 0.1$) and not on phytase level, but again, the interaction between experimental factors was significant ($P < 0.05$). Dietary supplements did not affect laying rate directly, but their effect was expressed in the significance of phytase x CD interaction. Both phytase level and CD significantly altered shell breaking strength ($P < 0.05$ and 0.01 , respectively).

Table 1: Influence of phytate conversion degree (CD: L- no addition, H- phytase B), and phytase (none, or 3- or 6 phytase A) on feed consumption (FC), feed per egg (FE), egg production (EP), egg weight (EW), laying rate (LR), egg shell breaking strength (SBS) and egg shell thickness (STH)

CD	PhytaseA	FC g-hen-day	FE g	EP kg	EW g	LR %	SBS N	STH
L	0	117 ^c	126	16.67	62.1 ^a	93.1 ^c	35.5 ^a	368
L	3A	117 ^c	133	16.12	65.5 ^{cd}	91.5 ^{bc}	36.2 ^a	365
L	6A	107 ^a	128	14.76	62.6 ^{ab}	80.8 ^a	40.0 ^b	379
H	0	116 ^{bc}	136	15.81	66.7 ^d	85.0 ^{ab}	37.7 ^{ab}	372
H	3A	112 ^{ab}	127	15.58	63.4 ^{ad}	88.3 ^{ac}	40.7 ^b	374
H	6A	116 ^{bc}	130	16.36	65.9 ^{cd}	89.0 ^{bc}	40.9 ^b	393
SEM		1.48	5.02	0.62	1.10	2.51	1.17	8.68
Probability								
Treatment effect		0.001	NS	NS	0.055	0.046	0.008	NS
CD		NS	NS	NS	0.054	NS	0.002	NS
Phytase A		0.024	NS	NS	NS	NS	0.050	NS
CD x phytase A		0.002	NS	NS	0.023	0.019	NS	NS

Table 2: As in Table 1; Effects in hens fed diets containing 3.6% Ca

CD	PhytaseA	FC g-hen-day	FE g	EP kg	EW g	LR %	SBS N	STH
L	0	109 ^a	128	15.39	64.6	85.4 ^a	35.8 ^a	372 ^a
L	3A	117 ^b	128	16.22	65.1	91.2 ^{bc}	40.6 ^c	382 ^{ab}
L	6A	117 ^b	127	16.49	64.0	92.4 ^c	39.0 ^{bc}	379 ^a
H	0	109 ^a	127	15.50	64.5	86.1 ^{ab}	37.4 ^{ab}	400 ^b
H	3A	117 ^b	130	16.39	65.2	90.1 ^{ac}	38.2 ^{ac}	363 ^a
H	6A	120 ^b	127	16.49	61.6	94.6 ^c	37.6 ^{ab}	372 ^a
SEM		1.79	3.15	0.43	0.77	1.63	0.99	6.86
Probability								
Treatment effect		0.004	NS	NS	NS	0.012	0.038	0.019
CD		NS	NS	NS	NS	NS	NS	NS
Phytase A		0.001	NS	NS	0.026	0.002	0.025	NS
CD x phytase A		NS	NS	NS	NS	NS	NS	0.005

At higher level of calcium (3.6 %) phytate conversion degree did not exert any effect on the parameters studied and the efficacy of both 3- and 6-phytases A was similar (Table 2). In the experiment, laying hens were fed low P diets containing either 2.6 or 3.6% Ca, so that

the influence of phytases A and CD on calcium metabolism is assessed. The most sensitive and commonly used indicators of Ca metabolism in laying hens are those related to eggshell quality (Gordon and Roland, 1998). At low level of Ca, the quality of eggshells measured as shell breaking strength was enhanced by both phytases A and also significant impact of the CD level was recorded. In fact, at low CD, only 6-phytase A improved shell breaking strength significantly, providing indirect evidence that myo-inositol phosphate intermediates produced by the enzyme modulate calcium metabolism by a highly specific mechanism that prevents metabolites of 3-phytase A to play a similar role. Yet another evidence of the existence of such a mechanism was provided by changes in feed consumption. The nature of the interaction between phytase and CD demonstrated that 6-phytase A reduced feed consumption only at the low CD and also that the increase in CD improved the efficacy of 6-phytase A and, at the same time, reduced the effectiveness of 3-phytase A. Many authors observed a positive effect of 3-phytase A on feed consumption in laying hens. All the observations reported previously by other research teams, however, have been performed exclusively at the low CD level, and, there are no literature data on the efficacy of 6-phytase A and phytase B in laying hens. In our study, at the low CD, there were also significant differences between the effectiveness of 3- and 6-phytase A in relation to egg weights. The mean weight of egg was enhanced by rising CD, and, again, the effectiveness of 6-phytase A was high only at the increased CD level. For laying rate, significant interaction between dietary factors was expressed in low values of the parameter in hens fed diet supplemented with 6-phytase A at low CD. The lack of response to dietary supplements observed for feed per egg conversion ratio as well as for egg production is consistent with findings provided by other researchers (Boling et al., 2000). All the observations show that in laying hens fed phosphorus and calcium deficient diets production parameters and egg shell quality are modulated by 6-phytase A differently than by 3-phytase A. Rising the phytate conversion degree by the addition of phytase B to feeds that had already been supplemented with a phytase A additionally affects hens performance in a way that depends on the type of phytase A involved. At higher level of calcium producing an imbalanced Ca/P ratio, phytate conversion degree and the type of phytase A do not seem to play any role in altering performance and egg shell quality in laying hens.

Myo-inositol phosphates released through simultaneous action of 3-phytase A and phytase B affect bird physiology differently than intermediates accumulated by the action of 6-phytase A and phytase B. This hypothesis has been substantiated by data obtained from experiments with growing broilers (Żyła et al, 2004) as well as laying hens. Simultaneous application of 3-phytase A and phytase B, on the one hand, and 6-phytase A along with phytase B on the other, offers a new and exciting area for future research that may benefit also the practice of commercial poultry production.

References

- BOLING, S.D., DOUGLAS M.W., JOHNSON M. L., WANG X., PARSONS C.M., KOELKEBECK K. W. and ZIMMERMAN R.A.** (2000) The effects of dietary available phosphorus levels and phytase on performance of young and older laying hens. *Poultry Sci.* **79**: 224-230.
- GORDON, R W. and ROLAND, D.A.**, (1998) Influence of supplemental phytase on calcium and phosphorus utilization in laying hens. *Poultry Sci.* **77**: 290-294.
- ŻYŁA, K., WIKIERA A., MIKA M., STODOLAK B., KORELESKI J. and ŚWIĄTKIEWICZ S.**, 2004. Towards complete dephosphorylation and total conversion of phytates in poultry feeds. *Poultry Sci.* **83**: 1175-1186.