Influence of calcium and non-phytate phosphorus deficient diets with phytase on the performance of broilers, serum concentrations of minerals and the activity of alanine transaminase, aspartate transaminase and lactate dehydrogenase

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Abstract: An experiment was conducted to study the effect of microbial phytase (phyzyme XP5000G) supplementation in broiler chicks’ diets on the performance, serum total protein (TP), minerals (Ca, Mg and P) and the serum enzyme activities (AST, ALT, LDH). A reference diet adequate in calcium and non-phytate phosphorus (10.0 gkg⁻¹ Ca and 5 gkg⁻¹ nPP) and two deficient diets in Ca and nPP (8.5 gkg⁻¹ Ca and 3.5 gkg⁻¹ nPP, and 7.5 gkg⁻¹ Ca and 2.5 gkg⁻¹ nPP) with or without phytase (0 and 100mgkg⁻¹) were offered to broiler chicks from 1 to 21 days of age. Although the low-nPP diets had no significant effect on body weight gain (BWG) of chicks (p>0.05) They increased (p<0.01) feed intake (FI) and feed conversion ratio (FCR) when compared to the low-nPP diet supplemented with enzyme. Phytase had a favorable effect, although non-significantly, on BWG of chicks fed very low level of nPP. Enzyme reduced the feed intake (p<0.05) and improved the FCR of Ca-nPP deficient chicks (p<0.01). The decrease in Ca-nPP content in the diet caused a significant increase in serum concentration of Ca (p<0.05) and decrease in P concentration (p<0.05). Low Ca-nPP diets had no influence on serum Mg concentration. Dietary phytase reduced the Ca level and increased the P level (p<0.05) of serum in chicks fed with Ca-nPP deficient diets. The activity of LDH increased (p<0.01) in response to low dietary Ca and nPP, deficient but there was no influence on serum ALT and AST activity and TP content (p>0.05). Phytase supplementation reduced serum ALT (p<0.05) and had no effect on AST (p>0.05). Serum LDH activity further increased (p<0.01) by phytase supplementation. These results demonstrated that the performance of the chicks received low levels of Ca and nPP with phytase was improved and the serum parameters were comparable to those chicks fed with normal Ca-nPP diet.

Key words: phytate phosphorus, phyzyme, broiler performance.

Introduction
Most cereal grains and oilseeds contain phytin between 0.7% and 2%, which serves as the storage form of phosphorus, representing 50% to 85% of the total P (Cheryan 1980).

Dietary phytin P is poorly digested by monogastric animals, as seen in the excretion of considerable quantities of P in manure from intensive operations. The poor digestive utilization of phytin-bound P by poultry and its consequences on diet cost,
environment, and digestibility of minerals and proteins have led to extensive research efforts directed toward understanding the process of phytic acid digestion.

There are several reviews on nutritional (Cheryan, 1980, Ravindran et al., 1995, Selle et al., 2000, Adeola and Sands 2003) and environmental (Jongbloed and Lenis, 1998) consequences of phytin, as well as the application, structure, and kinetic properties of phytase (Dvorakova, 1998; Liu et al., 1998; Keshavarz, 2000; Yu et al., 2004). Phytase is an enzyme that hydrolyzes phytate to inositol and inorganic phosphate. The enzyme is at low level in the chicken gastro-intestinal tract but is present in some cereals such as wheat and triticale and at high concentration in microbial sources. Supplementation of diets with microbial phytase has proven to be an effective and realistic method for enhancing the digestibility of phytic acid (Nys et al., 1999). Phytase reduces the need for supplemental inorganic P to the diet and hence, the amount of P excreted into the environment (Coelho, 1999, Kies, 1999, Selle et al., 2000, Kies et al., 2001, Adeola and Sands 2003). However, little is known about the effect of diets deficient in Ca and nPP, and with phytase on serum enzyme activity of broiler chicks. Therefore, the objective of this experiment was to evaluate the effect of phytase on body weight gain, feed intake, feed conversion ratio, and serum concentrations of Ca, P, Mg and total proteins as well as the activity of enzymes AST, ALT and LDH, in corn-soy bean meal based diets deficient in Ca and nPP compared to a nutritionally adequate diet for broiler chicks.

**Materials and Methods**

Six hundred 1-day old Ross male, broiler chicks (43±1.5g BW) were allotted to five treatments in a completely randomized design. Each treatment was replicated four times with thirty chicks in each replicate. The chicks were provided the experimental diets and the experiment lasted for 21 days. The birds were housed in an environmentally controlled room with raised wire floors. They were exposed to continuous light for the first 2 days, then to 23 h light and 1h darkness until 21 days of age. Chicks, feed, and water were checked twice daily, and feed in the mash form and water was provided on an ad libitum basis throughout the experiment.

A corn-soybean meal diet (C-SBM), adequate in all nutrients (except Ca and nPP) for experimental purposes was used. The diet (Table 1) provided 220gkg⁻¹ crude protein and 2900 kcal MEkg⁻¹, and met all other nutrient requirements (NRC, 1994). The dietary treatments were: 1) C-SBM, 10gkg⁻¹ Ca and 5gkg⁻¹ nPP (Diet 1); 2) C-SBM, 8.5gkg⁻¹ Ca and 3.75gkg⁻¹ nPP (Diet 2); 3) C-SBM, 7.5gkg⁻¹ Ca and 2.5gkg⁻¹ nPP (Diet 3); 4) Diet 2 + 100mgkg⁻¹ phytase (Phyzyme XP5000G, Danisco Animal Nutrition, Marlborough, Wiltshire, SN8 1XN, UK); 5) Diet 3 + 100mgkg⁻¹ phytase. The amount of enzyme added to the diet was based on the manufacturer’s recommendations.

**Growth Performance**

At the end of experimental period, the birds were weighed and feed consumption was recorded for feed efficiency computation. Feed conversion ratio (FCR) was calculated from the ratio of feed intake (FI) to body weight gain (BWG) for the 21 days of experimental treatment.

**Serum Ca, P, Mg, ALT, AST, LDH and TOP**

At 21 days of age, two birds were randomly selected from each pen and blood samples (10ml) were obtained by bleeding. Blood tubes were centrifuged at 1200 ×g and supernatants were collected in 1.5 ml Ependorf tubes and deep frozen (−20 °C) until measurement of minerals (Ca, P, Mg), aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), and total protein (TOP) in serum using commercial diagnostic kits and according to the standard procedures (Eppendorf Blood Analyzer, Model EPOS 5060, Netheler-Hinz GmbH, Hamburg, Germany) (AOAC, 1990).

**Statistical Analysis**

The experiment had a complete random design (ANOVA) (Minitab 13.2 statistical package, Minitab Inc. State College) with a 2 × 2 factorial arrangement.
The influence of calcium and... (two diets deficient in Ca and nPP and two levels of enzyme) with a reference diet adequate in Ca and nPP with no enzyme. Fisher’s LSD method was used to find confidence intervals for all pairwise differences between means. The general linear model was used to determine the main effects of factors and any possible interaction between factors.

Results

The influence of phytase enzyme on body weight gain, feed intake, feed conversion ratio of the chicks and the concentration of Ca, Mg, P and TP in serum and the activity of enzymes ALT, AST and LDH, is shown in Table 2.

There was no significant difference (p>0.05) in BWG of chicks among treatments. However, those chicks offered with Ca-nPP deficient diets had lower BWG values than the Ca-nPP adequate diet. Adding phytase tended to increase the BWG of Ca-nPP deficient groups to the level of Ca-nPP adequate diet.

There was a numeric increase in feed intake of the birds who received the lowest level of Ca-nPP diet compared to Ca-nPP adequate birds (30g), but phytase reduced significantly (p<0.05) the amount of feed consumed by those chicks fed the diet with the lowest level of Ca-nPP by almost 100g.

Those birds offered with the lowest level of Ca-nPP diet had the highest FCR and the birds received the same diet with enzyme had the lowest FCR among all treatments (p<0.01).

The serum concentration of Ca decreased and concentration of P increased when the level of Ca and P in the experimental diet decreased (p<0.05). However, the serum concentrations of Ca and P in birds provided with the same diets containing enzyme, were comparable to Ca-nPP adequate diet.

Different dietary treatments had no effect on serum concentrations of Mg and TOP, and serum activity of AST.

The serum activity of ALT decreased and the activity of LDH increased (p<0.05) in response to the diets deficient in Ca-nPP. Phytase had no influence on ALT activity in Ca-nPP deficient birds (p>0.05). However the enzyme further increased the activity of LDH in Ca-nPP deficient groups (p<0.01).

Discussion

Almost 70-80% of the phosphorus in feedstuffs of plant origin and 61-70% phosphorus found in corn-soybean meal diets is in the form of phytate phosphorus (Kies et al., 2001, Naher 2002). The inability of poultry to utilize phytate phosphorus, due to lack of endogenous phytase, results in the addition of inorganic feed phosphates to poultry diets in order to meet the phosphorus requirements of poultry (Maenz and Classen 1998, Yu, et al., 2004).


As expected, a decrease in dietary calcium and available phosphorus caused a negative effect on overall performance of chicks. These results were in agreement with those reported by others (Qian et al., 1996, Punna and Roland 1999, Rama Rao et al., 1999, Yu et al., 2004). Similarly, the positive effect of phytase on performance of chicks seen in this experiment, has already been reported by many workers (Broz et al., 1994, Sebastian et al., 1996, Rama Rao et al., 1999, Ahmad et al., 2000, Yu et al., 2004). As shown here and indicated by others, microbial phytase seems to be effective in releasing Ca and P in diets deficient in Ca and P (Qian et al., 1996, Gordon and Roland 1998, Cabahug et al., 1999, Sohail and Roland, 1999). The beneficial effect of phytase on growth performance has been related to (1) the release of minerals and trace elements from complexes with phytic acid, and increase in digestibility and availability of macro- and micro-elements (Knuckles and Betschsrt 1987, Qian et al.,...
An investigation was carried out by Ahmed et al. (2004) on the performance of broiler chicks who were fed soybean meal (SBM) based diet incorporating phytase with the levels of 0.0, 0.50, 1.00 and 1.50 gkg⁻¹ diet for better utilization of the basal diet. It was noted that the growth rate, feed intake, feed consumption, dressing yield and profitability increased as the level of phytase supplementation increased. It was suggested that 1.50gkg⁻¹ phytase may be incorporated in SBM based broiler diets in order to overcome effectively overcome the antinutritive effect of phytate phosphorus on broiler performance.

An increase in serum concentration of Ca and a decrease in concentration of P in response to decreasing Ca and nPP levels of the diet, has also been observed in chickens and turkeys (Fernandes et al., 1999, Atia et al., 2000, Brenes et al., 2003). The increase in serum Ca level of experimental chicks in response to decreasing dietary Ca and nPP level, might be related to an increase in Ca retention, which has been also indicated by others (Taylor and Dacke 1984, Sebastian et al., 1996, Fernandes et al., 1999).

An increase in P retention in broilers and pullets fed low nPP diets was related to a decrease in plasma P, indicating that birds had a greater ability to retain P from diets with lower nPP content (Ravindran et al., 2000, Keshavarz 2000).

In this study, phytase supplementation to the low Ca-nPP diets reduced Ca and increased P concentrations in serum. Similar results have also been observed by Sebastian et al., (1996), Han et al., (1997), Orban et al., (1999), Rama Rao et al., (1999) and Hassen and Chauhan (2003), Brenes et al.,(2003) and Juanpere et al., (2004). Perney et al., (1993) and Ahmad et al., (2000) indicated that the decreased P excretion in birds fed low-P diets with phytase, might be due to the increased bioavailability of both P and Ca, because both are part of the same complex and are released by the phytase enzyme at the same time.

When birds were fed diets with phytase, the phosphate group of phytate was degraded and absorbed, and then used for growth. The increased bioavailability of dietary P by adding phytase has also
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been reported by Nys et al., (1999) and Leske and Coon (1999).

Dietary phytic acid might increase the excretion of endogenous compounds by broilers. However, the supplementation of phytase seems to reduce the excretion of compounds with endogenous origin (Cowieson et al., 2004).

In the present study, the concentration of total protein and magnesium were not affected either by the dietary concentration of Ca and nPP or by the presence of phytase in the diet. However, it has been documented that the serum total protein and magnesium levels significantly increased when the diet of chicks was supplemented with dietary phytase (Hassen and Chauhan 2003, Brenes et al., 2003).

In an experiment by Brenes et al., (2003), it was demonstrated that by decreasing the nPP levels in the diet, plasma Ca concentration as well as AST, ALP, and LDH activities were increased and plasma P and TOP content were reduced. Phytase supplementation increased linearly plasma Ca, P, Mg, and TOP content, and serum AST, ALT and LDH activities, but reduced linearly serum ALP activity.

A difference in an activity of serum ALT in response to Ca-nPP deficient diets demonstrated in here and reported by Brenes et al., (2003), could be due to the higher activity of enzyme ALT reported here. Adding phytase to the diet could not elevate the activity of the enzyme in this experiment, which is in contrast with their report.

The activity of enzyme AST was not affected either by changes in the dietary concentration of Ca

<table>
<thead>
<tr>
<th>Ingredients (gkg⁻¹)</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diet 1</td>
</tr>
<tr>
<td>Corn</td>
<td>533</td>
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<tr>
<td>Soybean Meal</td>
<td>394</td>
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<tr>
<td>Vegetable Fatty Acid</td>
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<tr>
<td>Di-Calcium Phosphate</td>
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<tr>
<td>Limestone</td>
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<tr>
<td>DL-Methionine</td>
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<tr>
<td>L-Lysine</td>
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<tr>
<td>Salt</td>
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<tr>
<td>Vitamin + Mineral Premix*</td>
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</table>

Chemical Analysis (calculated)

<table>
<thead>
<tr>
<th>Metabolizable Energy (kcal kg⁻¹)</th>
<th>2900</th>
<th>2900</th>
<th>2900</th>
</tr>
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<tbody>
<tr>
<td>Crude Protein</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>Crude Fiber</td>
<td>41.0</td>
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<td>41.2</td>
</tr>
<tr>
<td>Total Fat</td>
<td>49.4</td>
<td>43.1</td>
<td>40.5</td>
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<tr>
<td>Arginine</td>
<td>15.8</td>
<td>15.8</td>
<td>15.8</td>
</tr>
<tr>
<td>Lysine</td>
<td>13.0</td>
<td>13.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Methionine</td>
<td>5.4</td>
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<td>5.4</td>
</tr>
<tr>
<td>Methionine + Cystine</td>
<td>9.2</td>
<td>9.2</td>
<td>9.2</td>
</tr>
<tr>
<td>Threonine</td>
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<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Tryptophan</td>
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<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Total Calcium</td>
<td>10</td>
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<td>7.5</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>8.0</td>
<td>6.75</td>
<td>5.50</td>
</tr>
<tr>
<td>Non-Phytate Phosphorus</td>
<td>5.0</td>
<td>3.75</td>
<td>2.5</td>
</tr>
</tbody>
</table>

*, The vitamin and mineral premix supplied per kg of diet; Vit A 9000IU, Vit D3 2000IU, Vit E 18IU,
Vit B1 1.8mg, Vit B2 6.6mg, Vit B3 (Calcium Panthotenate) 10mg, Vit B5 (Niacin) 30mg, Vit B6 3mg, Vit B12 0.015mg, Biotin 0.1mg, Folic Acid 1.0mg, Cholin Chloride 500mg, Vit K 2mg, Manganese 99.2mg, Iron 50mg, Zinc 84.7mg, Copper 10mg, Iodine 1mg, Selenium 0.2mg.
and nPP or by supplementation of dietary phytase, which is in agreement with the results of Kundu et al., (2004).

Viveros et al., (2002) informed that by decreasing nPP levels of the diet, plasma Ca and Mg concentrations increased, and plasma P and TOP content as well as AST activity were reduced. Phytase supplementation increased plasma P level and serum AST activity, reduced plasma Ca and Mg contents and reduced serum ALT and LDH activities.

An elevation in activity of enzyme LDH in response to the low levels of Ca and nPP in the diet and further increase in LDH activity when the dietary phytase was supplemented has also been shown by Brenes et al., (2003). The activity of LDH is nonspecific for hepatocellular disease in birds and the enzyme has five isoenzymes, which occur in a wide variety of tissues (Zantop 1997, Thrall 2004). However, further studies are needed in order to clarify the influence of phytase on the function of the hepatic enzymes.

**Acknowledgment**

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**References**


3. Ahmed, F., Rahman, M. S., Ahmed, S. U. and Miah,
The influence of calcium and...


The influence of calcium and...


تأثیر چربی‌های غذایی دارای کم‌بود کلسترول و فسفر غیر فیتیانه به همراه فیتین بروی عملکرد رشدی، غلظت سرم املاح و فعالیت آنزیم‌های آلانین ترانس آمیناز، آسیب‌دیدگی ترانس آمیناز، لاکتات دهیدروژناز در جوجه‌های گوشته

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(دریافت مقاله: ۱ خرداد ۱۳۸۳، پذیرش نهایی: ۱ آذر ماه ۱۳۸۳)

تحت یک آزمایش تأثیر فیتین میکرو و سیر (فیبر آپیسک پی‌پی) در جیره غذایی جوجه گوشته بروی عملکرد دارند، ترتیب تا کرمین، املاح و فعالیت آنزیمی سرم (LDH, AST, ALT) مطابقه گردید. یک جیره مضر این کالی از لحاظ کلسترول و فسفر غیر فیتیانه (10 گرم در کیلوگرم، کلسترول و 5 گرم در کیلوگرم، فسفر غیر فیتیانه) (0.05) و یک جیره غذایی کم‌بود کلسترول و فسفر غیر فیتیانه بودند (0.05) گرم در کیلوگرم، کلسترول و 5 گرم در کیلوگرم، فسفر غیر فیتیانه) بودند و با آنزیم فیتاین تهیه و درختی تهیه گرده‌های مورد آزمایش از سن یک روزه تا ۳۱ روز تاریک گرفت. اگرچه جیره‌های دارای کم‌بود فسفر غیر فیتیانه تأثیر معنی‌داری بر روی آزمایش ورود نداشت (0.05) این جیره‌ها باعث افزایش خشکی و افزایش ضریب تبدیل غذایی (0.01) (p) در مقایسه با جیره‌های غذایی بروی همان همراه آنزیم فیتاین گردید. فیتاین تأثیر مثبت، اگرچه غذایی دارای کم‌بود فسفر غیر فیتیانه بودند، در نتیجه آزمایش کاهش کم‌بود فسفر غیر فیتیانه (0.05) و بهبود ضریب تبدیل غذایی جوجه‌های دریافت کننده غذایی کم‌بود کم‌بود کم‌بود فسفر غیر فیتیانه گردید (0.01) (p). کاهش فسفر غیر فیتیانه جیره، باعث افزایش کم‌بود سرمی (0.05) و کاهش فسفر غیر فیتیانه (0.05) (p) گردید ولی تاثیری بر روی نیتریژن سرمی نداشت (0.05) (p). افزایش فیتاین جیره باعث کاهش سالم کم‌بود سرمی (0.05) و کم‌بود فسفر غیر فیتیانه بود (0.05) (p). افزایش فیتاین جیره در LDH (0.01) (p) تحت تأثیر چربی‌های غذایی کم‌بود کلسترول و فسفر غیر فیتیانه بود. در حالی که تاثیری در مردان آزمایشی در LDH و همچنین آزمایشی در مردان مشابه نکرد (0.05) (p). نتایج نشان داشت که فعالیت کم‌بود فسفر غیر فیتیانه (0.05) (p) و تاثیری در عملکرد LDH و AST (0.05) (p) نداشت. نتایج فعالیت سرمی آنیمیزهALT تحت تأثیر فیتاین بیشتری درینوده (0.01) (p).

واژه‌های کلیدی: فیتینه‌ها فسفر، فیتاین، بروی پرورش. Email: mansoori@ut.ac.ir - ۰۲۱-۶۴۴۴۳۳۳۳۳۳۳۳۳۳۳۳۳۳