The Effect of Phytase and Organic Acid on Growth Performance, Carcass Yield and Tibia Ash in Quails Fed Diets with Low Levels of Non-phytate Phosphorus

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ABSTRACT : An experiment was conducted to investigate the effect of phytase, organic acids and their interaction on body weight gain, feed consumption, feed conversion ratio, carcass yield and tibia ash. A total of 680 three-day old Japanese quail chicks (Coturnix coturnix japonica) were assigned to 20 battery brooders, 34 chicks in each. The experimental period lasted 35 days. The treatment groups employed were: 1) a positive control which included 3.5 g available phosphorus (AP)/kg diet and 10 g Ca/kg diet; 2) a negative control which included 2 g AP/kg diet and 8 g Ca/kg diet, 3) negative control diet supplemented with either 300 FTU phytase/kg diet (phytase) or 4) 2.5 g organic acid (lactic acid+formic acid)/kg diet (organic acid); or 5) 300 FTU phytase/kg diet+2.5 g organic acid/kg diet (phytase+organic acid). All birds were fed with the positive control diet for a week and then transferred to the dietary treatments. At the end of the study, there were no differences (p>0.005) among the groups in body weight, weight gain, feed consumption, feed conversion ratio and carcass yield. Tibia ash, however, was reduced (p<0.001) for quails fed the negative control diet containing a low-level of AP compared to the positive control diet containing adequate AP. The addition of phytase, organic acid or phytase+organic acid to the diets containing the low-level of AP improved (p<0.001) tibia ash. On the other hand, an extra synergistic effect of phytase and organic acid on tibia ash was not determined. This study demonstrated that it may be possible to reduce supplemental level of inorganic P with phytase and/or organic acid supplementation for quail diets without adverse effect on performance and tibia ash. (Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 2 : 198-202)

Key Words : Non-phytate Phosphorus, Organic Acid, Phytase, Quail, Tibia Ash

INTRODUCTION

About two-thirds of the total phosphorus (P) present in most feedstuffs used in poultry diets is in the form of phytate which is unavailable for monogastric animals due to insufficient quantities of endogenous phytate (Nelson, 1967). Thus, the bioavailability of P in feedstuffs of plant origin is generally very low. Bioavailability estimates of P in corn and soybean meal for pigs and poultry range from 10 to 30% (Nelson, 1967; Jongbloed and Kemme, 1990). In addition to low P availability, phytate limits availability of several other essential nutrients. Formation of insoluble phytate makes both Ca and P unavailable. Phytic acid has chelating potential forming a wide variety of insoluble salts with di- and trivalent cations at neutral pH (Vohra et al., 1965; Oberleas, 1973). Phytase, (myo-inositol hexakisphosphate phosphohydrolase), is the enzyme that releases P from phytate molecule (Gibson and Ullah, 1990). The efficacy of microbial phytase to improve dietary bioavailability has been reported by several researchers (Simons et al., 1990; Nair and Duvnjak, 1991; Denbow et al., 1995; Kornegay et al., 1996; Gordon and Ronald 1997; Sohail and Roland, 1999; Selle et al., 2003; Yan et al., 2003).

Organic acids are widespread in plant and animal tissues. It was reported that propionic, formic, citric, lactic and ascorbic acid increased nutrient digestibility without deleteriously affecting performance. It was reported that phosphorus utilization was improved by dietary citric acid in broilers (Boling et al., 2001) and dietary lactic acid or formic acid in pigs (Jangbloed et al., 2000). The main function of Ca and P is in the make up of the bones of the body. The young quail needs a minimum of 0.8% of the diet as Ca and 0.45% as available phosphorus. The use of phytase or organic acid alone or in combination could possibly reduce the need for inorganic P supplementation and increase nutrient bioavailability of corn-soybean meal quail diets. Thus, it may be possible to reduce environmental pollution resulted from phosphorus excretion.

The previous experiments clearly indicated that individually phytase and organic acids increase the availability of P in corn-soybean meal diets. There is no data on the use of phytase and organic acid combination in quail rations. The use of phytase or organic acid alone or in combination could possibly reduce the need for inorganic P supplementation. The primary objective of the current study was to determine the effect of phytase, organic acid and their interaction on body weight gain, feed consumption, feed conversion ratio, carcass yield and tibia ash.

MATERIALS AND METHODS

A total of 680 three-day old Japanese quail chicks (Coturnix coturnix japonica) were weighed, and assigned to
THE USE OF PHYTASE AND ORGANIC ACID IN QUAIL DIET

20 battery brooders, 34 chicks in each. The experimental period lasted 35 days. The experiment was conducted by using a corn-soybean meal based diet. Dietary treatments consisted of: 1) a positive control which included 3.5 g available phosphorus (AP)/kg diet and 10 g Ca/kg diet; 2) a negative control which included 2 g AP/kg diet and 8 g Ca/kg diet, 3) negative control diet supplemented with 300 FTU phytase (Ronozyme™ P, ROCHE)/kg diet (Phytase); or 4) 2.5 g organic acid (Nutrilac™, NUTRI-AD INTERNATIONAL)/kg diet (mainly lactic acid+formic acid) (Organic Acid); or 5) 300 FTU phytase/kg diet+2.5 g organic acid/kg diet (Phytase+Organic Acid). All diets were isocaloric and isonitrogenous to supply the same amount of energy and protein to all the birds in those groups (Table 1).

All birds were fed with the positive control diet for a week and then transferred to the dietary treatments. Three-day old quail chicks (n = 680) were placed in electrically heated, wire-floored battery brooders (91 cm x 45 cm x 23 cm) which are 5 tiered and 2.35 cm of feeder space per bird. Continuous light was provided with day light and 20 watt light bulb. Heating was provided with rod radiant (temperature was 35°C at first and reduced 3°C each week). Feed and water were offered ad libitum.

Chemical analyses of the diets used in the experiment were done using the methods of the AOAC (1984) and metabolisable energy of diets was determined according to the method suggested by Carpenter and Clegg (1956). Mean body weights of each brooder were determined at 3, 10, 17, 24, 31 and 38 d; cage feed consumption was measured for the same period. Mortality was recorded on a daily basis. At the end of the study, four male quails from each brooder were selected randomly and weighed and slaughtered. Tibias were obtained from two of the slaughtered quails and removed for bone ash determination as described by AOAC (1984).

Data on performance parameters and tibia ash were analysed by one-way ANOVA. The significance of differences between treatment means was tested according to Duncan, (1955). Differences in mortality rate were evaluated by Chi-Square test (Snedecor and Cochran, 1980). Statistical analyses were done using the SPSS program (version 10.0, USA). Statements of statistical significance are based on p<0.05.

RESULTS AND DISCUSSION

The supplementation of phytase or organic acid alone or in a combination with the low-level AP diets had no significant (p>0.05) effect on body weight, body weight gain, feed consumption, feed conversion ratio (Table 2) at any age during the study. Also, no interaction between phytase and organic acid were observed.

Reducing AP (to 2 g AP/kg diet) and Ca (to 8 g Ca/kg diet) without or with phytase or organic acid had no

### Table 1. Composition of the experimental diets fed to quails (g/kg)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive control</td>
</tr>
<tr>
<td>Corn</td>
<td>533.7</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>403.2</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>29.6</td>
</tr>
<tr>
<td>Limestone</td>
<td>12.9</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>13.7</td>
</tr>
<tr>
<td>Salt</td>
<td>2.0</td>
</tr>
<tr>
<td>Vitamin premix*</td>
<td>2.5</td>
</tr>
<tr>
<td>Mineral premix**</td>
<td>1.0</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.4</td>
</tr>
</tbody>
</table>

** Orchis Soy 4%, Valepoph 3%, calcium carbonate 4%, calcium phosphate 3%, salt 2%, vitamin premix: vitamin A: 15,000 IU; vitamin E-15 IU; vitamin K<sub>2</sub>: 2.5 mg; vitamin B<sub>1</sub>: 1 mg; vitamin B<sub>2</sub>: 10 mg; niacin: 70 mg; calcium-D-pantothenate: 20 mg; vitamin B<sub>6</sub>: 4 mg; folic acid: 2 mg; biotin: 0.1 mg; BHT: 125 mg.

1 diet was supplemented with 300 FTU phytase/kg diet.
2 diet was supplemented with 2.5 g organic acid/kg diet.
3 diet was supplemented with 300 FTU phytase/kg diet+2.5 g organic acid/kg diet.

* Provided per kg of diet: vitamin A: 15,000; vitamin D3: 3,000 IU; vitamin E-15 IU; vitamin K<sub>2</sub>: 2.5 mg; vitamin B<sub>1</sub>: 1 mg; vitamin B<sub>2</sub>: 10 mg; niacin: 70 mg; calcium-D-pantothenate: 20 mg; vitamin B<sub>6</sub>: 4 mg; folic acid: 2 mg; biotin: 0.1 mg; BHT: 125 mg.

** Provided per kg of diet: manganese: 80 mg; iron: 25 mg; zinc: 50 mg; copper: 7 mg; iodine: 0.3 mg; selenium: 0.15 mg; choline chloride: 350 mg.
Table 2. The effect of phytase and organic acid on body weight, feed consumption, body weight gain and feed conversion ratio of quails

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Positive control</th>
<th>Negative control</th>
<th>Phytase</th>
<th>Organic acid</th>
<th>Phytase+ organic acid</th>
<th>P</th>
<th>LSD value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>BW (g)</td>
<td>15.48±0.45</td>
<td>15.36±0.43</td>
<td>16.09±0.47</td>
<td>15.47±0.48</td>
<td>0.21</td>
<td>0.73</td>
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<tr>
<td>17</td>
<td></td>
<td>57.25±1.54</td>
<td>56.89±1.15</td>
<td>57.53±1.68</td>
<td>56.65±1.00</td>
<td>0.81</td>
<td>3.87</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td>143.00±1.13</td>
<td>142.10±1.36</td>
<td>145.05±2.39</td>
<td>139.65±0.61</td>
<td>0.31</td>
<td>5.12</td>
</tr>
<tr>
<td>3-17</td>
<td>FC (g)</td>
<td>113.19±3.59</td>
<td>114.00±6.17</td>
<td>114.95±7.53</td>
<td>110.30±5.80</td>
<td>0.76</td>
<td>8.32</td>
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<tr>
<td></td>
<td>BWG (g)</td>
<td>41.78±3.22</td>
<td>41.54±2.00</td>
<td>41.42±2.83</td>
<td>41.17±1.62</td>
<td>0.71</td>
<td>3.50</td>
</tr>
<tr>
<td></td>
<td>FCR</td>
<td>2.72±0.15</td>
<td>2.74±0.04</td>
<td>2.78±0.09</td>
<td>2.68±0.08</td>
<td>0.38</td>
<td>0.14</td>
</tr>
<tr>
<td>17-38</td>
<td>FC (g)</td>
<td>330.00±19.81</td>
<td>343.96±13.93</td>
<td>350.23±21.52</td>
<td>335.80±8.69</td>
<td>0.46</td>
<td>23.74</td>
</tr>
<tr>
<td></td>
<td>BWG (g)</td>
<td>85.74±1.42</td>
<td>85.20±4.15</td>
<td>87.52±3.67</td>
<td>83.00±1.81</td>
<td>0.33</td>
<td>4.97</td>
</tr>
<tr>
<td></td>
<td>FCR</td>
<td>3.85±0.27</td>
<td>4.04±0.31</td>
<td>4.00±0.15</td>
<td>4.05±0.05</td>
<td>0.71</td>
<td>0.38</td>
</tr>
<tr>
<td>3-38</td>
<td>FC (g)</td>
<td>443.19±11.13</td>
<td>457.96±9.95</td>
<td>465.18±13.91</td>
<td>446.10±2.62</td>
<td>0.50</td>
<td>28.79</td>
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<tr>
<td></td>
<td>BWG (g)</td>
<td>127.52±1.14</td>
<td>126.74±1.50</td>
<td>128.94±2.23</td>
<td>124.17±0.34</td>
<td>0.38</td>
<td>4.93</td>
</tr>
<tr>
<td></td>
<td>FCR</td>
<td>3.47±0.06</td>
<td>3.61±0.10</td>
<td>3.61±0.05</td>
<td>3.59±0.01</td>
<td>0.66</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Values represent the mean±SE.

FC: Feed consumption; BWG: Body weight gain; FCR (FC/BWG): Feed conversion ratio; LSD: Least square deviation; p>0.05.

negative effects on growth parameters as compared to positive control diet containing 3.5 g AP/kg and 10 g Ca/kg. Similar to the present study, Waldroup et al. (1974) reported that in two of three trials, 1.2 g AP/kg diet (lowest level tested) was adequate for body weight gain and feed conversion ratio in broilers 4 to 8 weeks of age. In a third trial no more than 2.4 g AP/kg diet was required. More recently, it was reported that removal of supplemental phosphate sources from corn-soybean meal diets fed to broilers from 42 to 49 d or 42 to 56 d (Skinner et al., 1992a, 1992b) and 42 to 63 d (Yan et al., 2003) did not adversely affect body weight gain and feed conversion ratio. Singh et al. (2003) reported that phytase supplementation to low NPP (0.30%) diets improved the growth performance, relative retention of nutrients (N, Ca and P) and minerals (Ca, P) status of blood and bone in broiler chickens, with a better efficacy in maize based diets.

However, in numerous studies (Denbow et al., 1995; Qian et al., 1996; Cabahug et al., 1999; Sohail and Roland, 1999), while body weight gain, feed intake and feed conversion ratio were decreased by a low-level AP diet, supplementation of phytase to the diet improved performance of broilers. The results obtained from the present study were consistent with the previous reports that inclusion of 50 g lactic acid/kg diet did not affect live weight, weight gain (Yağcı et al., 1997). On the other hand, it was reported that the addition of 30 g (Cave, 1984; Pinchasov and Jensen, 1989), 50 g (Lessard et al., 1993) and 75 g (Jacob et al., 1990) lactic acid/kg diet to the broiler rations numerically reduced body weight and weight gain. In contrast to results in our study, addition of 20, 40 and 60 g citric acid/kg diet resulted in increases in body weight gain and feed conversion ratio (Boling et al., 2000b, 2001).

In general, feed consumption and feed conversion ratio followed a similar pattern to that of body weight gains. In this study, feed consumption and feed conversion ratio were affected by neither low-level AP diet nor the addition of phytase or organic acid alone or in combination to the diet. It was reported that supplementation of 10, 30 g lactic acid/kg diet to the adequate level AP diets had no significant effect on feed consumption in broilers 21 to 29 day (Cave, 1984) and 21 to 28 day (Pinchasov and Jensen, 1989) of age. In the study conducted by Jacob et al. (1990), while feed consumption was not affected by 25 g Ca-lactat/kg diet, it was decreased by 50 g and 75 g Ca-lactat/kg diet.

In this study, feed consumption for per kg weight gain was not affected by reducing AP with or without phytase or organic acid. The present results were in agreement with previous reports of studies that used lactic acid (Pinchasov and Jensen, 1989; Yağcı et al., 1997). In contrast to these results, Lessard et al. (1993) reported that feed conversion ratio was improved by 50 g lactic acid/kg diet supplementation at the rate of 7% compared to control group. All discrepancies reported in performance values can be attributed to changes in phosphorus requirement of chicks with the age, size and strain of birds in addition to dietary, management and environmental factors. At the end of the experiment, slaughtered quails had similar carcass weight and carcass yield.

The addition of phytase or organic acid alone or in combination to the low-level AP diet had no significant effect on carcass percentage of quails slaughtered at 38 days of age. Although live performance is an important measure of dietary changes, when available phosphorus and Ca levels or one of the two in the diet are changed, bone
parameters are generally more sensitive than performance. A significant effect of phytase and organic acid supplementation was revealed on tibia ash. The inclusion of 300 FTU phytase/kg diet, 2.5 g organic acid/kg diet and 300 FTU phytase/kg diet+2.5 g organic acid/kg diet resulted in a significant (p<0.001) increase in tibia ash (Table 3). The present results are in agreement with numerous previous reports that using phytase (Denbow et al., 1995; Qian et al., 1996; Cabahug et al., 1999; Sohail and Roland, 1999; Yan, et al., 2003), and citric acid (Boling et al., 2000a, b; 2001).

This study demonstrated that it may be possible to reduce supplemental level of inorganic P with phytase and/or organic acid supplementation for quail diets. However no synergetic effect was observed between phytase and organic acid on performance or tibia ash content.

Based on the results of this study, the following conclusions were drawn: 1) performance parameters were not adversely affected by a reduction of AP to 2 g/kg diet and Ca to 8 g/kg diet as compared to diet containing 3.5 g AP/kg diet and 10 g Ca/kg diet. 2) The negative effect on tibia ash associated with a dietary level of 2 g AP/kg diet and 8 g Ca/kg diet was completely reversed by the inclusion of 300 FTU phytase/kg diet or 2.5 g organic acid/kg diet either alone or in a combination. 3) Combination of phytase and organic acid in diet provided no additional benefit.

### REFERENCES


Qian, H., H. P. Veit, E. T. Kornegay, V. Ravindran and D. M. Denbow. 1996. Effect of supplemental phytase and phosphorus

### Table 3. The effect of phytase and organic acid on carcass weights, carcass yield and tibia ash of quails

<table>
<thead>
<tr>
<th></th>
<th>Positive control</th>
<th>Negative control</th>
<th>Phytase</th>
<th>Organic Acid</th>
<th>Phytase+Organic Acid</th>
<th>P</th>
<th>LSD value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass weight (g)</td>
<td>100.06±1.57</td>
<td>99.13±1.13</td>
<td>100.19±1.54</td>
<td>100.75±2.09</td>
<td>99.87±1.61</td>
<td>0.97</td>
<td>4.55</td>
</tr>
<tr>
<td>Carcass yield (%)</td>
<td>71.35±0.51</td>
<td>70.76±0.59</td>
<td>71.27±0.55</td>
<td>71.89±0.53</td>
<td>71.60±0.44</td>
<td>0.64</td>
<td>1.48</td>
</tr>
<tr>
<td>Tibia ash (%)</td>
<td>41.35±0.63b</td>
<td>39.46±1.06a</td>
<td>41.37±0.66</td>
<td>41.10±0.47</td>
<td>41.28±0.34b</td>
<td>0.00***</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Values represent the mean±SE. *b Row means with common superscript do not differ (p>0.05), ***p<0.001; LSD: least square deviation.
on histological and other tibial bone characteristic and performances of broilers fed semi-purified diets. Poult. Sci. 75:618-626.


