Effect of phytase with or without multi-enzyme supplementation on performance and nutrient digestibility of young broiler chicks fed mash or crumble diets

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Abstract

A total of 210 unsexed 1-day old Arbor Acres broiler chicks were wing banded and randomly distributed among 30 cages of 7 birds per cage keeping equal initial BW during days 1-20 of age. A factorial design (2x3) was used in which there were two feed forms (mash vs crumble diet) and three enzyme treatments (unsupplemented, phytase, phytase plus multi-enzyme). Each treatment was replicated five times with 7 chicks per replicate. Body weight (BW), body weight gain (BWG) and feed conversion ratio (FCR) of fed chicks were significantly improved when the crumble diet was administered. However, feed intake of chicks fed on the crumble diet was significantly lower than those fed the mash diet. Digestibility of ether extract and crude fiber was significantly greater in groups fed the crumble diet than those fed the mash diet. Enzyme supplementation significantly and similarly increased growth and production index, and improved FCR. Also greater digestibility of crude protein and crude ash was observed but growth during days 8-14 of age and crude fibre digestibility were significantly greater in chicks receiving the multi-enzyme plus phytase supplement than those receiving phytase alone. Crumble feed supplemented with multi-enzyme resulted in the highest performance and nutrient digestibility of broilers during days 1-20 of age.

Introduction

Between 60% and 70% of the total production cost of poultry is related to the cost of feedstuffs and the choice of poultry feeds is, therefore, of great economic importance. The efficient use of feed is extremely important in broiler production. Mash is a form of a complete feed that is finely ground and mixed so that birds cannot easily separate out ingredients; consequently, each mouthful provides a well-balanced diet. A simple manufacturing procedure is needed for the mash form of feed. Mendes et al. (1995) showed that birds fed mash diets had a better feed conversion efficiency than those given pellet diets. Also, crumble is a type of feed prepared at the mill by pelleting the mixed ingredients and then crushing the pellet to a consistency coarser than mash. This form of feed is very convenient to use and this has led, over recent years, to its increased popularity among broiler producers. However, pellet or crumble cost slightly more than the same ration in mash form (Cutlip et al., 2008). Reece et al. (1984) observed that feed conversion ratio (FCR) was improved in broilers fed a high-energy and protein crumble diet. In addition, Choi et al. (1986) reported that chicks fed the crumbled starter diet consumed more feed. Furthermore, growth performance of broilers fed a crumble or pellet diet was better than those fed on mash feed (Jahan et al., 2006; Cutlip et al., 2008). Pelleting or crumbling improved nutrient digestibility, decreased feeding time, and was easier to eat (McKinney and Teeter, 2004; Skinner-Noble et al., 2005; Amerah et al., 2007; Cerrate et al., 2009; Yang et al., 2010; Attia et al., 2012). Jafarnejad et al. (2010) reported that body weight (BW) and FCR were significantly improved in broilers fed crumble-pellet diets compared with those fed mash diets.

Most of the feed ingredients used in the poultry diet contain non-starch polysaccharides (NSPs) and phytates at different concentrations. The anti-nutritional effects of NSPs have been reported (Choch and Annison, 1999; Choch, 2006; Attia et al., 2008). Birds do not produce enzymes, such as cellulase, xylanase, phytase etc., that are required for the digestion of NSPs and phytates. Supplementation of NSP degrading enzymes and phytase may not only reduce the anti-nutritive effects of NSPs and phytates (Attia, 2003), but also releases some nutrients that could be utilised by the birds (Attia et al., 2003a, 2003b, 2008). Supplementing multi-enzyme or phytase to corn-soy based broiler diets increased growth performance in comparison to unsupplemented diets (Kavitha et al., 2003; Choct, 2006). However, improved performance of poultry depends on dietary composition and type of supplemented enzyme (Attia, 2003; Abudabos, 2012; Nourmomhadi et al., 2012). The use of an enzyme complex containing carbohydrases and phytase should improve the ability of broilers, laying hens, ducks and Japanese quail to use the energy, protein, P and Ca they obtain from the diet (Attia, 2003; Attia et al., 2003a, 2003b, 2008; Cowieson et al., 2006; Yang et al., 2010) and a small amount of these nutrients can be added to the diet. This study aimed to evaluate the effect of phytase with or without multi-enzyme supplementation on performance and nutrient digestibility of young broiler chicks fed mash or crumble diets.

Materials and methods

The study was conducted at the Poultry Research Station, Department of Animal and Poultry production, Faculty of Agriculture, Damanhour University, Egypt, from April to May 2011.

Chicks

A total of 210 unsexed 1-day old Arbor Acres broiler chicks were obtained from a commercial hatchery, wing banded and randomly distributed keeping equal initial BW in 30 cages of 7 birds per replicate (cage). There were 5 replicates per treatment.
Experimental design

A factorial experimental design (2x3) was used during days 1-20 of age, in which there were two feed forms (mash vs crumble diet) and three enzyme treatments (unsupplemented, Phytase, Phyzyme® XP and multienzyme containing Avizyme 1505 plus Phyzyme® XP). There were 3 subgroups within each mash or crumble diet (2 mm). Pelleting temperature did not exceed 80°C. Phyzyme and Avizyme are products of Danisco Animal Nutrition (Marlborough, Wiltshire, UK). Avizyme® 1505 is a multienzyme containing 1500 U/g endo-1, 4-β-xylanase, 2000 U/g α-glucamylase and 20,000 U/g α-subtilisin, and the recommended dose for use in broiler and turkey diets is 0.20 g per kg of diet. Phyzyme® XP is an Escherichia coli phytase classified as a 6-phytase with hydrolysis of the phosphate moiety being initiated at the 6-position on the phytate molecule; its recommended dose for use in broiler and turkey diets is 500 units of phytase per kg of diet. The available phosphorus (avP) and Ca contents were adjusted in the diets supplemented with phytase according to phytase equivalent values (Attia, 2003; Attia et al., 2003a; Choct, 2006) (Table 1).

Housing and husbandry

Chicks were housed in battery brooders in semi-opened house. They were fed the experimental diets ad libitum and given free access to water. A light schedule similar to that used under commercial conditions was implemented until day 7, i.e. 23 h light followed by 20 h light from day 8 throughout the experimental period until day 20 of age. The average outdoor minimum and maximum temperatures and relative humidity during the experimental period were 21.2 and 24.2°C and 56.7 and 58.7%, respectively. Indoor brooding temperature was 32.2, 29.4 and 26.7°C during days 1-7, 8-18 and days 15-20 of age. Chicks were vaccinated with Hitchiner + IB, Influenza H5 N2 and Gumboro at days 8, 11 and 13 of age.

Data collection

Birds were weighed (g) individually at days 1, 7, 14 and 20 of age and bird weight gain (BWG) (g/bird) was calculated. Feed intake was recorded for each replicate (g/bird) and mortality rate was calculated according to the AOAC (1995). European Production Efficiency Index (EPEI) was calculated using the equation set out in the Hubbard Broiler Management Guide (1999) as follows:

\[
EPEI = \frac{BW \times SR}{PP \times FCR} \times 100
\]

where PP is Production Period (days).

Results

Body weight and body weight gain

The effects on growth of broiler chicks of diet and/or enzyme supplementation are shown in Table 1. Body weight and BWG from day 8 of age of broilers fed a crumb diet was significantly higher than those fed a mash diet. Multi-enzyme + phytase supplementation resulted in significantly higher BW at day 14 and BWG in the period days 8-14, while phytase and multi-enzyme + phytase groups gave significantly higher BW at day 20 and BWG in the period days 1-20 than the control group.

A significant interaction between form of feed was determined according to the AOAC (1995). European Production Efficiency Index (EPEI) was calculated using the equation set out in the Hubbard Broiler Management Guide (1999) as follows:

\[
EPEI = \frac{BW \times SR}{PP \times FCR} \times 100
\]

where PP is Production Period (days).

Mortality rate was analysed as percent using \( \chi^2 \) analyses.

Table 1. Ingredients and chemical composition of the experimental diets given during starter stages.

| Ingredients, g/kg | Control | Diet Multienzymes | Phytase |
|------------------|---------|------------------|---------|
| Maize            | 512.5   | 512.5            | 512.5   |
| Soybean meal, 44% CP | 328.2   | 328.2            | 328.2   |
| Vegetable oil    | 22.5    | 22.5             | 22.5    |
| Full fat soybean meal | 100.0   | 100.0            | 100     |
| Dicalcium phosphate | 18.0    | 13.0             | 13.0    |
| Limestone        | 10.0    | 10.0             | 10.0    |
| L-Lysine         | 1.0     | 1.0              | 1.0     |
| DL-Methionine    | 1.5     | 1.5              | 1.5     |
| Vitamin+mineral premix° | 3.0   | 3.0              | 3.0     |
| NaCl             | 3.0     | 3.0              | 3.0     |
| Avizyme 1505     | 0.0     | 0.2              | 0.0     |
| Phyzyme® xp      | 0.0     | 0.07             | 0.07    |
| Washed building sand | 0.30   | 5.03             | 5.23    |
| Total            | 1000    | 1000             | 1000    |

| Calculated and determined composition |
|--------------------------------------|
| Dry matter, g/kg                           | 866.8      | 866.8 | 866.8 |
| Metabolizable energy, MJ/kg               | 12.72      | 12.72 | 12.72 |
| Crude protein, g/kg                       | 228        | 228   | 228   |
| Lysine, g/kg                              | 13.3       | 13.3  | 13.3  |
| Methionine, g/kg                          | 5.0        | 5.0   | 5.0   |
| Methionine + cystine, g/kg                | 8.7        | 8.7   | 8.7   |
| Calcium, g/kg                             | 9.1        | 8.0   | 8.0   |
| Total phosphorus, g/kg                    | 6.0        | 5.0   | 5.0   |
| Available phosphorus, g/kg                | 4.6        | 3.7   | 3.7   |
| Crude fat, g/kg                           | 60.9       | 60.9  | 60.9  |
| Crude fibre, g/kg                         | 35.5       | 35.5  | 35.5  |
| Ash, g/kg                                 | 52.2       | 52.2  | 52.2  |
| NFE, g/kg                                 | 623.4      | 623.4 | 623.4 |

*Hi•Min mixture/kg diet: 24 mg, vitamin A (retinyl acetate); 20 mg, vitamin E (α-tocopherol acetate); 2.3 mg, menadione; 0.05 mg, vitamin B12 (choriocalciferol); 5.5 mg, riboflavin; 12 mg, calcium pantothenate; 50 mg, nicotinic acid; 600 mg, choline chloride; 10 g, vitamin B6; 3 mg, vitamin B3, 3 mg, thiamine; 1 mg, folic acid; 0.50 mg, d biotin; 80 mg, Mn; 60 mg, Zn; 35 mg, Fe; 8 mg, Cu; 0.60 mg, Se. NFE, nitrogen-free extract. °Calculated values.
diet and enzyme supplementation was shown only on BWG during days 8-14 of age.

**Feed intake and feed conversion ratio**

Data concerning FI and FCR of broiler chicks as affected by form of diet and/or enzyme supplementation are shown in Table 3. Feed intake was significantly decreased in chickens fed on the crumble feeds compared with those fed the mash feed except only during the period days 8-14 of age. In addition, enzyme supplementation significantly decreased feed intake compared to the control group only during days 15-20 of age. The results showed that chicks fed a diet supplemented with multienzyme with phytase consumed significantly less feed than broilers fed a diet supplemented with phytase alone. There was no significant effect on FI from interaction between form of diet and enzymes during any of the test periods.

| Treatment                          | Body weight according to age, g | Body weight gain, g |
|------------------------------------|---------------------------------|--------------------|
|                                    | 1d     | 7d     | 14d    | 20d    | 1-7d    | 2-10d   | 8-14d   | 15-20d |
| **Main effects**                   |        |        |        |        |         |         |         |        |
| Feed form                          |        |        |        |        |         |         |         |        |
| Mash                               | 44.7   | 170    | 317    | 669    | 125     | 624     | 146a    | 352    |
| Crumble                            | 44.5   | 169    | 358    | 764    | 124     | 733     | 204a    | 404    |
| Enzyme supplementation             |        |        |        |        |         |         |         |        |
| Control                            | 44.8   | 170    | 339    | 721b   | 125     | 637b    | 156a    | 345    |
| Phytase                            | 44.4   | 169    | 348b   | 745b   | 124     | 701b    | 174b    | 397    |
| Multienzyme + phytase              | 44.5   | 169    | 361c   | 754c   | 125     | 709c    | 192c    | 389    |
| **P value**                        |        |        |        |        |         |         |         |        |
| Feed form                          | ns     | ns     | 0.001  | 0.001  | ns      | 0.001   | 0.001   | 0.001  |
| Enzyme supplementation             | ns     | ns     | 0.001  | 0.041  | ns      | 0.037   | 0.001   | ns     |
| Feed form x enzyme supplementation | ns     | ns     | ns     | ns     | ns      | ns      | 0.001   | ns     |

Means in the same column followed by different letters are significantly different at P ≤ 0.05; ns, not significant. SEM, standard error of mean.

**Table 3. Effects of feed form and phytase with or without multienzyme supplemenations on feed intake and feed conversion ratio of broiler chicks during days 1-20 of age.**

| Treatment                          | Feed intake, g/bird | Feed conversion ratio, g feed/g gain |
|------------------------------------|---------------------|-------------------------------------|
|                                    | 1-7d    | 8-14d | 15-20d | 8-14d | 15-20d | 1-20d    |
| **Main effects**                   |         |       |        |       |        |         |
| Feed form                          |         |       |        |       |        |         |
| Mash                               | 193     | 193   | 193a   | 90    | 0.024  | 0.026    |
| Crumble                            | 179     | 179   | 182    | 102   | 0.027  | 0.027    |
| Enzyme supplementation             |         |       |        |       |        |         |
| Control                            | 183     | 182   | 182    | 109   | 1.48   | 1.50     |
| Phytase                            | 182     | 182   | 182    | 109   | 1.48   | 1.50     |
| Multienzyme + phytase              | 182     | 182   | 182    | 109   | 1.48   | 1.50     |
| **P value**                        |         |       |        |       |        |         |
| Feed form                          | 0.001   | ns    | ns     | 0.001 | 0.001  | 0.001    |
| Enzyme supplementation             | ns      | ns    | ns     | 0.001 | 0.001  | 0.001    |
| Feed form x enzyme supplementation | ns      | ns    | ns     | ns    | ns     | ns       |

Means in the same column followed by different letters are significantly different at P ≤ 0.05; ns, not significant.
Feed conversion rate was significantly lower in chicks fed crumble than those fed the mash diet. Both enzymes significantly improved FCR compared with the unsupplemented group from day 8 of age. There was no significant effect on FCR from interaction between form of diet and enzyme supplementation during the entire experimental period.

Apparent digestibility of nutrients

Data concerning the effects of form of diet and enzyme supplementation on apparent digestibility of nutrients of broiler chicks are shown in Table 4. Results showed a significantly higher EE and CF digestibility from crumble feeds than the mash diet, but diet form and enzyme supplementation did not affect digestibility of DM, CP and CA. Groups fed diets supplemented with both enzymes showed significantly higher digestibility of CF, CF and CA than the control group. However, multienzyme plus phytase induced significantly greater CF digestibility than phytase alone. There was no significant difference in effect on apparent digestibility of nutrients between the different diets and enzyme supplementation.

Mortality rate

There was no significant effect on mortality rate according to form of diet and enzyme supplementation (Table 5).

Production index

The production index (Table 5) was significantly higher in groups fed crumble than those fed a mash diet. In addition, both enzymes resulted in a significantly greater production index than the control group. There was no significant interaction between form of diet and enzyme supplementation on production index.

Discussion

Feeding crumble diets increased BW (12.7%) and BWG (13.7%), improved FCR (16.8%), and decreased the feed intake (5.7%) compared to those of chicks fed on mash diets. This coincided with the greater digestibility of EE (9.5%) and CF (23.4%), and resulted in a higher production index (27.5%). These results are similar to those reported by Nir et al. (1995), Engberg et al. (2002), Svihus et al. (2004) and Cutlip et al. (2008). These improvements have been variously attributed to increased nutritional density, increased nutrient intake, changes in the physical form of the feed, reduced feed wastage, decreased energy expenditure while eating (McKinney and Teeter, 2004; Skinner-Noble et al., 2005; Amerah et al., 2007; Cerrate et al., 2009; Yang et al., 2010), increased starch digestibility (Parsons et al., 2006), and improved apparent metabolisable energy (AME) and nutrient retention (Svihus et al., 2004; Adeyemi et al., 2008). The combination of thermal and

| Table 4. Effects of feed form and phytase with or without multienzyme supplementations on apparent nutrient digestibility of nutrients of broiler chicks at day 20 of age. |
|-------------------------------------------------|------------------|------------------|------------------|------------------|
| Treatment                                       | Dry matter       | Crude protein    | Ether extract    | Crude fibre      |
| Mash control                                    | 71.1             | 65.3             | 66.2             | 10.0             | 16.4             |
| Mash + phytase                                  | 72.5             | 68.9             | 70.1             | 12.4             | 25.2             |
| Mash + multienzyme + phytase                    | 69.8             | 71.3             | 70.8             | 14.4             | 25.6             |
| Crumble control                                 | 70.9             | 68.4             | 73.7             | 13.5             | 18.0             |
| Crumble + phytase                               | 70.9             | 72.0             | 76.4             | 14.5             | 25.8             |
| Crumble + multienzyme + phytase                 | 70.9             | 70.9             | 76.7             | 17.5             | 24.6             |
| SEM                                             | 0.97             | 1.36             | 1.47             | 0.54             | 1.15             |
| Main effects                                    |                  |                  |                  |                  |
| Feed form                                       |                  |                  |                  |                  |
| Mash                                            | 71.1             | 68.5             | 69.0             | 12.3             | 22.4             |
| Crumble                                         | 70.9             | 70.4             | 75.6             | 15.2             | 22.8             |
| Enzyme supplementation                          |                  |                  |                  |                  |
| Control                                         | 71.0             | 66.8             | 69.9             | 11.8             | 17.2             |
| Phytase                                         | 71.7             | 70.4             | 73.3             | 13.5             | 25.5             |
| Multienzyme + phytase                           | 70.3             | 71.1             | 73.8             | 16.0             | 25.1             |
| P value                                          |                  |                  |                  |                  |
| Feed form                                       | ns               | ns               | 0.001            | 0.001            | ns               |
| Enzyme supplementation                          | ns               | 0.025            | ns               | ns               | ns               |
| Feed form x enzyme supplementation              | ns               | ns               | ns               | ns               | ns               |

**Main effects**

**P value**

**Table 5. Effects of feed form and/or phytase with or without multienzyme supplementation on mortality rate and production index of broiler chicks during days 1-20 of age.**

| Treatment                                       | Mortality rate, % | Production index |
|-------------------------------------------------|-------------------|------------------|
| Mash control                                    | 97.1              | 182              |
| Mash + phytase                                  | 97.1              | 193              |
| Mash + multienzyme + phytase                    | 97.1              | 196              |
| Crumble control                                 | 97.1              | 239              |
| Crumble + phytase                               | 97.1              | 286              |
| Crumble + multienzyme + phytase                 | 97.1              | 280              |
| SEM                                             | 0.12              | 5.78             |

**Main effects**

**P value**

*Means in the same column followed by different letters are significantly different at P≤0.05; ns, not significant.
Phytase and multi-enzyme in broiler diets

mechanical action resulted in a rupture of the cell walls and thus made encapsulated nutrients of the feedstuff more accessible to digestive enzymes (Vande and Schrijver, 1988; Cutlip et al., 2008).

Phytase and multi-enzyme plus phytase supplementation increased BW (3.3 and 4.6%) and BWG (3.7 and 4.9%), improved FCR (4.8 and 6.6%), and decreased feed intake by 1.6 and 2.2%, respectively, of the improvement in FCR as compared with those chicks fed a diet without enzyme supplementation. The positive effect of enzymes on growth performance of broilers was observed along with increasing nutrient digestibility, e.g. CP (5.4 and 6.3%), CF (14.5 and 35.8%), CA (48.2 and 45.8%), and production index (10.2 and 15.1%), respectively. These results are in agreement with those reported by Al-Harthi (2006) and Attia et al. (2003a, 2003b, 2008). The improvement in BW and BWG which resulted from supplementation of either multi-enzyme plus phytase or phytase alone may be due to the improvement in the availability and absorption of nutrients through increasing the digestibility of the ingested diets, as proposed by Attia (2003), Chot (2006), Abudabos (2012), and Nourmohammadi et al. (2012). However, the effect of phytase and multi-enzyme depends on dietary composition and type of enzyme (Zanella et al., 1999; Attia, 2003). Phytase and/or avizyme improved BWG and FCR while it decreased feed intake (Attia et al., 2001; Al-Harthi, 2006) showing that diet supplementation with a combination of avizyme and phytase significantly increased growth during days 7-21 of age; this could be attributed to the presence of amylase and NSP degrading enzymes (Cowie et al., 2003; Ghazalah et al., 2005). The form of feed and/or two enzymes had no significant effect on mortality rate; this is similar to reports by Deaton (1992), Cerrate et al. (2009) and Dozier et al. (2010), Jahan et al. (2006) and Tufarelli et al. (2011) reported that the physical form of diet had no influence on the health status of poultry. In addition, enzyme supplementation to the barley-based diet had no significant impact on mortality (Shirzadi et al., 2008).

The beneficial effect of crumble feed and/or enzyme supplementation on production index is in line with that reported by Attia et al. (2003) and Jahan et al. (2006).

The significant interaction between form of feed and enzyme supplementation on BWG during days 8-14 of age, showing the effect of enzyme, depends on type of diet (crumble vs mash) with a phytase-induced greater effect on growth of the crumble diet than the mash diet (7.4 vs 2.7%). In addition, multi-enzyme plus phytase had a greater effect on the crumble than on the mash diet. The use of an enzyme complex containing carbohydrases and phytase was suggested as a tool to decrease dietary concentration of nutrient, i.e. avP, AME, CP/amino acids, and Ca in poultry feeds due to improved nutrient utilisation (Attia, 2003; Attia et al., 2001; Cowieson et al., 2006; Yang et al., 2010). However, the lack of a significant interaction effect on performance and nutrient digestibility for the whole study period indicated that either multi-enzyme plus phytase or phytase alone may be adequate, that supplementation to mash or crumble feeds is essential, and that the influence of enzymes is independent of type of feed.

Conclusions

Crumble form of feed supplemented with multi-enzyme plus phytase or phytase alone improved the performance and nutrient digestibility, and multi-enzyme plus phytase resulted in the highest production index of broiler chicks.

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