Effect of enzyme supplementation and wheat middlings as an alternative to corn on laying hens performance

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Abstract

A 7-week trial examined the effects of dietary enzyme supplementation (ES), a combination of xylanase, amylase and protease on egg production, egg mass, feed conversion ratio (FCR) and nutrient retention in Hy-Line W-36 strain fed diets containing wheat middlings (WM) combined with Avizyme 1500 enzyme (xylanase, protease and amylase) at different dietary metabolizable energy (ME) levels. Seven diets were assigned to five replicate pens with 4 hens per pen from 44 to 51 week of age. The collected data indicated no significant difference in feed consumption, egg production, egg mass and body weight occurred among hens fed the dietary treatments. Egg weight responded significantly to ES (P<0.01), especially when hens were fed the low energy diet with ES. Egg components were not affected by diet or by ES. Apparent ME was affected significantly by diet (3071 for control vs 2920 kcal/kg for WM diets). Type of diet had the most significant effect on performance while ES to WM diets at this phase of production had little effect on performance or apparent nutrient retention especially when it was supplemented to the low energy diets. Including WM in laying hen diets up to 30% did not affect most measured parameters and could serve as a good alternative to corn depending on the price of corn.

Introduction

High grain prices have caused poultry industry to consider wheat and wheat by-products as alternatives to corn (Ward, 1995). A number of researchers have found that wheat by-products can be a good substitute for corn in poultry feeds and can be used up to 40% in the layers diet (Dale, 1996; Patterson et al., 1988; Jaroni et al., 1999a; Ahmad and Karimov, 2010). When the more common poultry ingredients, such as corn, become expensive, then wheat middling (WM) could serve as a major feed ingredient.

Wheat middling contains a class of poorly-digested substances called non-starch polysaccharides (NSPs), which are considered the major antinutritive factors in cereals and other varieties of feed ingredients (Annison, 1990; Choc and Annison, 1991; Choc et al., 1996). The endosperm cell wall of wheat is mainly composed of arabinoxylans (Annison and Choc, 1991; Classen and Bedford, 1991). Water soluble NSPs fed to poultry are indigestible and also interfere with the digestion of other nutrients by increasing the viscosity of digesta in the small intestine, which impairs absorption of nutrients (Ward and Marquardt, 1983).

Exogenous enzymes added to the feed or used during feedstuff processing have the potential to improve feed efficiency, reduce pollution associated with poultry manure, and increase the use of low-cost feed ingredients (Choc et al., 1995). Enzymes are usually added to grain-based poultry feeds to affect hydrolysis of NSP fractions that cannot be digested by the birds’ own enzyme secretions (Classen and Bedford, 1991; Bedford, 1995). Improvements in gain, feed efficiency, intestinal viscosity, digesta dry matter, and digestibility are often associated with enzyme addition to cereal-based diets (Patridge and Wyatt, 1995; Mathlouthi et al., 2002; Jaroni et al., 1999a). Data indicated a small but significant reduction in digesta viscosity with enzyme supplementation (ES) of wheat-based diets, which correlates well with weight gain and feed conversion ratio (FCR). The energy content of feed is one of the most important considerations in reducing the costs of poultry production, because birds tend to over-consume low-energy rations compared to high energy ones (Hill et al., 1956). A major factor in poultry production is the extent to which energy from feedstuffs is converted into energy useful to the birds (Patrick and Schaible, 1981). Mathlouthi et al. (2002) reported that low dietary metabolizable energy (ME) significantly reduced the performance of laying hens, while the addition of the xylanase restored the performance of layers fed a low energy diet. The objective of the present study was to test the effectiveness of a commercial enzyme supplement, in diets containing 2 levels of WM inclusion (20 and 30%) and 2 levels of ME (low and normal), compared to a standard corn-soy diet. Factors examined were hen performance, egg mass, feed intake, egg composition and nutrient retention [crude protein (CP), Calcium (Ca), phosphorus (P) and apparent metabolizable energy (AME)].

Materials and methods

Experimental design

A control corn-soy diet was compared to 6 diets containing wheat middlings. Two levels of WM inclusion (20 and 30%) and two levels of ME (low and normal) were used with or without enzyme supplementation, for a total of 7 treatments. All 7 diets were fed to birds of one strain of single-comb white leghorn hens (Hy-line W-36) from 44 to 51 wk of age, for a total time period of 7 wk. Each treatment was assigned to 5 replicate pens with 4 hens per pen (412 cm2/ bird) for a total of 35 pens. The individual pen was the experimental unit.

Diets

The experimental diets were formulated to meet National Research Council (1994) nutrient requirements for laying hens, in particular the recommendations for phase II of the Hy-line strain (Table 1). However, the low-ME diets were formulated to have 40 kcal/kg below
the Hy-line W-36 recommendations (2860 vs 2820 kcal/kg diet).

Diet 1 was the control corn-soybean meal; diet 2 contained 20% WM with ES; diet 3 contained 20% WM, a normal ME without ES; diet 4 same as in diet 3 with ES; diet 5 contained 30% WM with low ME and ES; diet 6 contained 30% WM with normal ME without ES; diet 7 same as in diet 6 with ES. The supplement used in this experiment was a microbial multi-enzyme containing 300 U/g xylanase, 4000 U/g protease, and 400 U/g α-amylase.

Measurements

Feed consumption and egg production were measured daily, and egg production calculated on a hen/day basis. Hens had access to 115 g of feed ad libitum each day. Unconsumed feed was measured each morning and calculated daily on a hen/day basis. Egg mass was calculated as a factor of egg weight and egg production. All hens were individually weighed every 2 weeks. Feed conversion was calculated as g of feed consumed per g of egg mass produced.

One day of egg production was used to measure egg weight and to examine eggs for shell quality by specific gravity. One egg per pen was used to determine haugh unit value (Haugh, 1937). Biweekly, two eggs per pen were saved for egg break out to determine percent albumen, yolk, yolk solid, and shell. Yolk colour was measured biweekly on one egg per pen by using the Roche colour fan (Vuilleumier, 1969) and colour values for L* (lightness), a* (redness), and b* (yellowness), using a Minolta chromometer measuring Hunter lab trisums system (Fletcher, 1992).

At 51 wk of age one hen from each pen was euthanized by cervical dislocation to measure gut viscosity. All diets were supplemented with 3 g kg\(^{-1}\) chronic oxide as an analytical marker for measurement of Ca, P and CP retention and determination of AME; the intestine was removed and the contents of the small intestine from Meckels diverticulum to the ileal-cecal-colon junction were collected to determine the digesta supernatant viscosity. Approximately 1.5 g of homogenized chyme sample was immediately placed in a micro centrifuge tube and centrifuged at 12,700 x g for 5 minutes. Viscosity was directly measured on a 0.5 mL sample of supernatant using a Brookfield viscometer. Three readings were taken and then averaged for statistical analysis. Viscosity was expressed in centipose units (cp). The same samples were used to determine ileal digestibility.

At the end of the experiment, hens were fed chromium oxide mashed feed for 5 days and on the 5th day approximately 400 g of clean excreta was collected to determine nutrients retention (Ca, P, CP and AME). Excreta and ileal digesta samples were freeze-dried, ground to pass a 1.0 mm screen, and then analyzed for gross energy content using a Parr adiabatic oxygen bomb calorimeter equipped with a digital thermometer. Nitrogen, Ca, and P content were determined using the standard procedure described in Association of Official Analytical Chemists (AOAC, 1994).

Chronic oxide was analyzed using the procedure described in Williams (Williams et al., 1962). AME values were determined using the following equation (Scott et al, 1976):

\[
\text{AME (kcal/kg of diet)} = \text{GE diet} - (\text{GE excretes} or \text{digesta} \times \text{Marker diet/Marker excretes or digesta})
\]

The following equation was used for calculation of the nutrient retention:

\[
\text{Retention = 100} - ((\text{Diet Cr}_2\text{O}_3 / \text{Fecal Cr}_2\text{O}_3 \times \text{Fecal nutrient/diet nutrient}) \times 100
\]

Table 1. Composition of the experimental diets.

| Ingredients                  | Control  | 20% WM low ME, diet 2° | 20% WM normal ME, diet 3 and 4° | 30% WM low ME, diet 5° | 30% WM normal ME, diet 6 and 7° |
|------------------------------|----------|------------------------|---------------------------------|------------------------|--------------------------------|
| Corn, %                      | 65.8     | 45.6                   | 44.5                             | 33.9                   | 32.9                            |
| Soybean meal, %              | 15.9     | 12.6                   | 12.5                             | 12.0                   | 11.8                            |
| Wheat middlings, %           | 0.0      | 20.0                   | 29.0                             | 30.0                   | 30.0                            |
| Tallow, %                    | 1.0      | 5.1                    | 5.9                              | 5.1                    | 5.1                             |
| Corn gluten meal, %          | 5.9      | 5.9                    | 6.0                              | 5.3                    | 5.1                             |
| Limestone, %                 | 7.4      | 7.3                    | 7.3                              | 7.3                    | 7.3                             |
| Dicalcium phosphate, %       | 1.7      | 1.5                    | 1.4                              | 1.3                    | 1.3                             |
| Oyster shell, %              | 1.5      | 1.5                    | 1.5                              | 1.5                    | 1.5                             |
| Salt, %                      | 0.5      | 0.37                   | 0.37                             | 0.35                   | 0.35                            |
| DL-Methionine, %             | 0.05     | 0.06                   | 0.06                             | 0.07                   | 0.07                            |
| Lysine, %                    | 0.16     | 0.19                   | 0.2                              | 0.08                   | 0.08                            |
| Trace mineral, %             | 0.16     | 0.1                    | 0.1                              | 0.1                    | 0.1                             |
| Vitamin premix, %            | 0.05     | 0.05                   | 0.05                             | 0.05                   | 0.05                            |
| Protein calculated, %        | 16.5     | 16.5                   | 16.5                             | 16.5                   | 16.5                            |
| Protein analyzed, %          | 17.3     | 17.4                   | 17.9                             | 17.9                   | 17.8                            |
| ME, kcal/kg                  | 2869     | 2820                   | 2869                             | 2820                   | 2869                            |
| Calcium calculated, %        | 4.0      | 4.0                    | 4.0                              | 4.0                    | 4.0                             |
| Calcium analyzed, %          | 3.5      | 3.8                    | 4.0                              | 3.5                    | 4.3                             |
| Available phosphorus, %      | 0.4      | 0.4                    | 0.4                              | 0.4                    | 0.4                             |
| TSAA, %                      | 0.66     | 0.66                   | 0.66                             | 0.66                   | 0.66                            |
| Lysine, %                    | 0.85     | 0.85                   | 0.85                             | 0.85                   | 0.85                            |

*Diets 2, 4, 5, and 7 had 0.10% added to the basal diet; † mineral-vitamin premix provided: Mn, 88 mg; Cu, 6.6 mg; Zn, 88 mg; Se, 0.3 mg; vitamin A, 6600 U; cholecalciferol, 2805 U; vitamin E, 10 U; vitamin K, 2.0 mg; riboflavin, 4.4 mg; pantothenic acid, 6.5 mg; niacin, 24.2 mg; choline, 110 mg; vitamin B12, 8.8 mg; ethoxyquin, 1.1 mg; per kg diet. ME, metabolizable energy; TSAA, total sulfur amino acid.
Feed efficiency, egg mass and body weight change

Feed consumption showed no significant difference between hens fed the corn-soy diet and the WM diets (96.6 g/d vs 100.6 g/d, respectively; P>0.05). Enzyme supplementation or energy level had no significant effect on feed consumption (Table 2). This is in agreement with previous findings (Patterson et al., 1988; Roberts and Bregendahl, 2006; Ahmadi and Karimov, 2010) and in disagreement with others (Patterson et al., 1987; Bai et al., 1992), who reported that hens fed with WM diets increased feed consumption. Feed intake was not affected by ES, similar results was reported by other researchers (Vukic et al., 1993; Pan et al., 1998; Jaroni et al., 1999a).

Egg production was not affected by ES, energy level or by type of diet (P>0.05). Enzyme supplementation did not improve egg production, in accordance with other studies (Patterson et al., 1987; Al-Bustany and Elwinger, 1988). However, other studies found a significant effect for ES on egg production; Jaroni (1999a) found that adding protease and xylanase to WM diets can improve the egg output without affecting production parameters. Mathlouthi et al. (2002) reported that xylanase supplementation to wheat based diet improved egg production and egg mass of layers fed the low energy diet. Hens fed the WM diets produced similar eggs compared to the control diets. These results are in accordance with those obtained by Jaroni (1999a), Roberts and Bregendahl (2006) and Ahmadi and Karimov (2010), who reported similar egg production for hens fed control and WM diets. Patterson et al. (1987) found that overall hen/day production rates among the control, the 20% WM diet and a 43% WM diet were not significantly different; but the production rate was reduced when hens fed an 89% WM diet. Egg weight was significantly affected by treatment (P<0.01). Enzyme affected the 20% WM diet (P<0.01) such that the hens fed the supplemented version of this diet produced heavier eggs compared to the unsupplemented (61.1 g vs 58.9 g, respectively). Hens fed the low energy supplemented 20 and 30% WM produced heavier eggs than the hens fed the normal energy not supplemented 20% and 30% (61.1 and 61.9 vs 58.9 and 59.8 g; P<0.01). Egg mass was not influenced by dietary treatments (Table 2).

Jaroni (1999a) observed a significant effect on average egg weight when enzyme was added to a WM diet. Several authors found the same effect for the enzyme (Brufau et al., 1994; Francesch et al., 1994; Mathlouthi et al., 2002) who noticed an increase in egg weight with enzyme addition to layers fed wheat based diets. Even though, ES improved egg weight but it did not improve egg mass to a significant level; type of diet also had no significant effect on egg mass. Feed conversion ratio was affected by type of diet (P<0.05) (Table 2). Hens fed the control diet had a FCR lower than those fed the WM diets (1.797 vs 1.910). These results agree with previous findings (Patterson et al., 1987; Bai et al., 1992). In contrast, Patterson et al. (1988) did not find significant differences in FCR between laying hens fed diets containing 20 or 25% WM compared to the control. Recently, Ahmadi and Karimov (2010) found no significant differences in FCR in layer hens which had received WM at 3 levels (7.5, 15.0 and 22.5) compared to control. Body weight was not affected by any dietary treatment, during the experiment period.

Table 2. Effect of dietary treatments on hen performance.

| Diet     | WM, % | Energy, kcal/kg | Enzyme, % | Feed intake, g/d | Egg production, % | Egg weight, g | Egg mass, g/hen/d | FCR, g:g | Body weight change, g |
|----------|-------|----------------|-----------|-----------------|------------------|--------------|-----------------|---------|----------------------|
| 1        | 0     | 2860           | 0.0       | 96.6            | 90.7             | 59.8         | 54.42           | 1.797   | 269.4                |
| 2        | 20    | 2830           | 0.1       | 102.3           | 88.5             | 61.1         | 54.11           | 1.910   | 427.0                |
| 3        | 30    | 2860           | 0.0       | 97.0            | 88.8             | 58.9         | 52.28           | 1.878   | 386.8                |
| 4        | 30    | 2860           | 0.1       | 98.9            | 89.6             | 61.1         | 54.66           | 1.815   | 472.6                |
| 5        | 30    | 2830           | 0.1       | 101.5           | 84.3             | 61.9         | 52.22           | 1.983   | 353.8                |
| 6        | 30    | 2860           | 0.0       | 100.6           | 89.3             | 59.1         | 52.80           | 1.909   | 317.8                |
| 7        | 30    | 2860           | 0.1       | ±1.93           | ±1.41            | ±0.52        | ±0.99           | ±0.03   | ±82.92               |

Enzyme average

|       | With |         | Without |         |                  |              |                  |        |
|-------|------|---------|---------|--------|------------------|--------------|------------------|--------|
|       | 99.8 | 88.9    | 100.1   | 89.5   | 59.4             | 53.73        | 1.894            | 395.2  |
|       | 42   | 59.8    | 42     | 60.4   | 53.70            | 1.868        | 428.6            |        |
| 20    | 99.4 | 89.0    | 101.8   | 87.5   | 60.3             | 52.70        | 1.953            | 344.3  |

Statistical probabilities

| Treatment | ns | ns | 0.002 | ns | 0.01 | ns |
|-----------|----|----|-------|----|------|----|
| Control   |    |    |       |    |      |    |
| Contrasts |    |    |       |    |      |    |
| With vs with enzyme |    |    |       |    |      |    |
| 20% WM with vs without enzyme |    |    |       |    |      |    |
| 30% WM with vs without enzyme |    |    |       |    |      |    |
| Treatment 2 with 3 |    |    |       |    |      |    |
| Treatment 5 with 6 |    |    |       |    |      |    |

WM, wheat middlings; FCR, feed conversion rate; ns, not significant.
Egg composition, haugh unit, and yolk colour

Percentage of albumen, yolk, and shell were not affected by any of the dietary treatments (Table 3). Haugh unit values and specific gravity were similarly unaffected by treatment (data not shown). Lightness (L*) values were not affected by any of the treatments (Table 3). Redness (a*) and yellowness (b*) values were affected by the type of diet, with the yolk redness values of eggs produced by hens fed the control diet being higher than the redness for hens on the WM diets (0.37 vs -0.78; P<0.001). Yellowness value was also higher for hens on the control diet than on the WM (51.6 vs 47.2, respectively; P<0.001) (Table 3). On the other hand, hens fed the low ME 30% WM with ES had a higher redness value than those fed the control energy 30% WM diet. Enzyme supplementation to WM diets was diluted by replacing corn. The corn-soy diet had higher redness and yellowness values than the WM-containing diets.

Viscosity and nutrient retention

Intestinal viscosity was not influenced by dietary treatment (Table 4). The excreta CP retention was affected significantly by the type of diet (P<0.001) (Table 4). Enzyme failed to lower gut viscosity to a significant level. Other researchers (Chocht et al., 1996) have reported highly significant reductions in digesta viscosity after enzyme inclusion to wheat diet. While others reported that the addition of enzymes to a layer diets did not alter chyme viscosity (Jaroni et al., 1999b; Marsman et al., 1997).

Hens fed control diet retained more CP than those fed diets containing WM (47.9 vs 34.8%). Enzyme had no overall effect on CP retention. On the other hand, excreta Ca retention also showed no significant differences between the control and WM diets (59.8 vs 48.8%). Ileal Ca retention was not affected by dietary treatments (Table 4). Excreta and ileal P retention were not influenced by diet. There was a tendency towards improvement in excreta P retention when enzyme was added to the 20 and 30% WM diets; however, the improvement was not significant. Excreta CP and Ca retentions were higher in the control diet compared to the WM diets. Enzyme supplementation to the WM diets failed to improve nutrient retention, whereas other researchers showed a positive effect of ES on nutrients retention. When examining the effect of xylanase and protease on the digestibility of protein in WM diet, Jaroni et al. (1999b) found that at 50 wk CP digestibility increased significantly with supplementation of enzyme, but at 60 wk all the treatments showed a similar response. Scheieler et al. (2005) reported that amylase, xylanase and protease enzyme preparation had a significant positive effect on CP retention in hens at 40 wk of age.

Apparent ME was affected by diet, with the control diet showing a significantly higher excreta AME value (3071 kcal/kg) than the WM diets (2920 kcal/kg; P<0.005). The normal-energy 30% WM diet showed a higher value than the 30% low-energy diet (2927 vs 2798 kcal/kg). However, the ileum AME was not affected by any treatment. The control corn-soy diet provided a higher AME than the WM diet despite an effort to formulate isocaloric diets. Enzyme failed to improve AME in hens which had received 30% WM with low energy diet to the level of normal ME (2798 vs 2927 kcal/kg, respectively). Enzyme did not improve AME in either excreta or ileum, contrary to the findings of other researchers (Rotter et al., 1990; Chocht et al., 1995). Mathiouhi et al. (2002) found that addition of xylanase to the low-energy diet was equivalent to an increase of at least 100 kcal ME/kg.

| Table 3. Effect of dietary treatments on egg components and yolk colour. |
|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Diet            | WM, %           | Energy, kcal/kg| Enzyme, %       | Albumen, %      | Yolk, %         | Solid yolk, %   | Wet shell, %    | Dry shell, %    | Fan, %          |
|                 |                 |                |                 |                 |                 |                 |                 |                 |                 |
| 1               | 0               | 0.0            | 0.0             | 58.8            | 28.4            | 14.1            | 11.1            | 9.1             | 56.7            | 0.37            | 51.6            | 8.5            |
| 2               | 20              | 0.1            | 0.1             | 58.5            | 29.5            | 14.6            | 10.7            | 8.6             | 57.5            | -0.76           | 49.1            | 8.2            |
| 3               | 30              | 0.0            | 0.0             | 58.2            | 28.9            | 14.3            | 10.6            | 8.6             | 56.0            | -0.74           | 46.9            | 8.1            |
| 4               | 30              | 0.1            | 0.1             | 58.1            | 29.5            | 14.6            | 10.8            | 8.8             | 56.4            | -0.40           | 47.0            | 9.0            |
| 5               | 30              | 0.0            | 0.0             | 59.5            | 28.5            | 14.3            | 10.6            | 8.6             | 56.0            | -0.73           | 47.1            | 8.8            |
| 6               | 30              | 0.0            | 0.0             | 58.2            | 28.9            | 14.4            | 11.1            | 9.0             | 56.5            | -1.44           | 46.6            | 7.9            |
| 7               | 30              | 0.1            | 0.1             | 59.8            | 28.6            | 14.2            | 10.4            | 8.6             | 56.9            | -1.07           | 46.6            | 8.1            |
| SEM             | ±0.71           | ±0.43          | ±0.22           | ±0.25           | ±0.16           | ±0.55           | 0.23            | 0.96            | 0.34            |
| Enzyme average  |                 |                |                 |                 |                 |                 |                 |                 |                 |
| With            |                 |                |                 |                 |                 |                 |                 |                 |                 |
| Without         |                 |                |                 |                 |                 |                 |                 |                 |                 |
| WM, % average   |                 |                |                 |                 |                 |                 |                 |                 |                 |
| 0               |                 |                |                 |                 |                 |                 |                 |                 |                 |
| 20              |                 |                |                 |                 |                 |                 |                 |                 |                 |
| 30              |                 |                |                 |                 |                 |                 |                 |                 |                 |
| Statistical probabilities |
| Treatment       | ns              | ns             | ns              | ns              | ns              | ns              | 0.001           | 0.01            | ns              |
| Contrast        |                 |                |                 |                 |                 |                 |                 |                 |                 |
| Control vs diets with WM | 0.001          | 0.001          |                 |                 |                 |                 |                 |                 |                 |
| With vs without enzyme |
| 20% WM with vs without enzyme |                 |                |                 |                 |                 |                 |                 |                 |                 |
| 30% WM with vs without enzyme |                 |                |                 |                 |                 |                 |                 |                 |                 |
| Treatment 2 vs 3 |                 |                |                 |                 |                 |                 |                 |                 |                 |
| Treatment 5 vs 6 |                 |                |                 |                 |                 |                 |                 | 0.05            |                 |

WM, wheat middlings; ns, not significant.
Table 4. Effect of dietary treatments on viscosity and retention.

| Diet | 0 | 2860 | 0.0 | 2.78 | 47.0 | 59.8 | 20.7 | 3071 | 76.6 | 94.8 | 42.4 | 2569 |
|------|---|------|-----|------|------|------|------|-------|------|------|------|------|
| 1    | 0 | 2820 | 0.1 | 3.37 | 37.3 | 55.2 | 10.9 | 2922  | 79.7 | 97.5 | 52.6 | 3093 |
| 2    | 20| 2860 | 0.0 | 3.76 | 34.2 | 55.6 | 18.7 | 2931  | 76.4 | 94.8 | 47.0 | 2741 |
| 3    | 20| 2820 | 0.1 | 3.51 | 32.1 | 56.9 | 20.3 | 2932  | 82.2 | 95.7 | 29.1 | 2917 |
| 4    | 30| 2820 | 0.1 | 3.11 | 32.5 | 47.7 | 14.7 | 2978  | 78.7 | 94.6 | 50.8 | 2893 |
| 5    | 30| 2860 | 0.0 | 3.45 | 36.8 | 45.8 | 9.4  | 2927  | 77.3 | 93.0 | 29.6 | 2591 |
| 6    | 30| 2860 | 0.1 | 2.88 | 36.2 | 31.6 | 15.9 | 3013  | 78.2 | 92.7 | 46.0 | 2797 |
| 7    | 30| 2820 | 0.1 |       |      |      |      |       |      |      |      |      |

SEM
With: ±0.32
Without: ±2.13
WM, % average: ±5.58
Enzyme, % average: ±4.20
AME, kcal/kg: ±38.08

Treatment 2 vs Control ns 0.001 0.02 0.001 ns ns ns ns
Treatment 2 vs 3 0.001 0.01 0.001
Treatment 2 vs 6 0.03

Type of diet had the most significant effect on performance, with birds receiving the corn-soy diets having better performance than those fed WM diets. Enzyme supplementation had a little effect on performance or nutrient retention. The addition of the enzyme to the low energy diets improved performance of layers, which reached that of normal energy diets. Differently the ES added to the normal energy diets did not result in any further improvement in performance. The results obtained here suggested that an inclusion rate of 30% WM in layer’s diet from 44 to 51 wk had no negative effect on performance and WM can serve as a viable alternative to corn in layer diets especially during periods of high corn prices. Different trials have given inconclusive results concerning the performance of layers fed wheat by product with enzymes. This fact may be due to differences in chemical composition of the wheat by products and inclusion rate in the diet, stage of egg production, enzyme cocktail composition and amount of the enzyme in the diet and the interactions between enzyme and other substances in the feed.

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