Effect of Dietary Supplementation with 1, 25- Dihydroxy Cholecalciferol (Calcitriol) on Performance, Tibia Mineral Alterations and Ileal Nutrient Digestibility in Laying Hens Fed Diets with Deficient Calcium-Phosphorus Level

Rahman Jahanian* and Elaheh Jahanian

Department of Animal Sciences, College of Agriculture, Isfahan University of Technology, Isfahan 84156-83111, IRAN

*Corresponding Author: r.jahanian@cc.iut.ac.ir

ABSTRACT
To investigate the effect of dietary calcitriol supplementation on performance, bone mineral turnover and ileal nutrient digestibility of laying hens fed diets deficient in calcium-phosphorus (Ca-P) level, 100 Hy-Line W-36 laying hens (56 wk-aged) were randomly distributed between 5 replicates of 4 dietary treatments. Experimental Diets included two dietary Ca-P levels (sufficient as recommended by Hy-line W-36 guideline versus 20% deficient) and two vitamin D sources (D3 or calcitriol), which fed during a 77 d trial period including 7 d for adaptation and 70 d as main recording period. The highest egg production allotted to the birds fed on Ca-P-sufficient diets supplemented with calcitriol. There was a significant (P<0.05) interaction between dietary Ca-P level and vitamin source in the light of egg production percentage so that, decrease in dietary Ca-P level was associated with higher decrease in egg production in calcitriol-supplemented diets than with D3-supplemented ones. Regardless of dietary Ca-P level, the best feed conversion ratios assigned to the calcitriol-supplemented birds. Dietary supplementation with calcitriol increased tibial Ca (P<0.01) and P (P<0.05) contents and the least concentration (P<0.05) of tibial Ca was observed in hens fed on Ca-P-deficient diets. Dietary treatments had significant (P<0.05) impacts on ileal digestibility coefficients of dry matter, Ca and ash; however, P and crude protein digestibilities weren't influenced by dietary Ca-P level or vitamin source. The present findings indicate that calcitriol supplementation of laying diets could improve overall performance and bone mineralization in layers.

Keywords: Laying hens, Calcitriol, Calcium and phosphorus, Performance, Tibial ash, Ileal nutrient digestibility

Introduction
Vitamin D, whether from the diet or produced in the skin by irradiation of 7-dehydrocholesterol by ultraviolet light, is converted to its active hormonal form 1,25-dihydroxycholecalciferol [1,25-(OH)2-D3 or calcitriol] by two sequential hydroxylation reactions (Norman et al., 1982). The first reaction occurs in the liver, forming 25-hydroxycholecalciferol [25-(OH)-D3] and the second in the kidney, forming 1,25-(OH)2-D3
Vitamin D or its active metabolite (1,25-dihydroxycholecalciferol) is involved in Ca and P absorption in the gut, bone mineralization (bone formation) and demineralization (bone mobilization), and Ca and phosphate resorption by the kidney (Combs, 1998). Manifestation of vitamin D deficiency is a complex phenomenon. Many investigators have considered animals to be vitamin D-deficient if they exhibit rickets, reduced intestinal calcium transport, hypocalcemia, or undetectable levels of 25-(OH)-D3 or 1,25-(OH)2-D3 (Kwiecinski et al., 1989; Walters et al., 1992). Vitamin D deficiency has pronounced growth-depressing effects on the ossified skeletal system in most animals (Bernard et al., 1989). In addition, Bethke et al. (1936) and Murphy et al. (1936) reported that D3 provided to hens and sunlight exposure affected bone calcification of the progeny and the mineral composition of the embryo. We hypothesized that if 1,25-dihydroxycholecalciferol is more potent in the absorption of calcium and phosphorus from the avian gut, so dietary supplementation with this active metabolite can reduce nutritional demands of Ca and P in laying hens. The present study, therefore, was conducted to comparatively investigate the effects of vitamin D3 and calcitriol on performance, tibial mineral content and ileal mineral digestibility in Leghorn laying hens.

Materials and Methods

The study presented here was carried out at the Poultry Research Station of Isfahan University of Technology (Isfahan, Iran) and all procedures used were approved by the Isfahan University of Technology Animal Care and Use Committee. A total of 100 Hy-Line W-36 laying hens of 56 weeks of age were randomly allocated into the 4 dietary treatments with 5 replicates of 5 birds each. Dietary treatments were consisted a 2×2 factorial arrangement of treatments with 2 dietary calcium/phosphorus levels (adequate amount as recommended by Hy-Line W-36 Management Guide and 20% deficient) and 2 vitamin D sources (D3 or calcitriol). The experimental diets were formulated according to Hy-Line W-36 recommendations (Hy-Line International, 2007), and were similar in nutrient composition except calcium and phosphorus contents. The experimental period lasted for a total of 10 wk started immediately after one week adaptation period. In addition to performance parameters (production percentage, egg weight, egg mass, feed intake, and feed conversion ratio), two birds per replicate were killed by cervical dislocation at the final day of trial and ileal contents from Merckel’s diverticulum to the ileal-cecal-colon junction were collected directly into 250-mL specimen cups (Scott and Boldaji, 1997). Prior to killing, the birds were fed with chromic oxide-containing diets (supplemented with 0.5% chromic oxide) for five day from 66th to 70th d of trial. The samples were held on ice, frozen (−20°C), freeze-dried, and stored for analysis. Feed samples and freeze-dried excreta were ground (0.5 mm screen) prior to chemical analysis. The samples were analyzed for crude protein, total ash, Ca, and P according to standard procedures of AOAC (2002). Furthermore, the left tibias of the birds were removed and frozen (−20°C) until further analysis for ash, Ca, and P contents. All data were subjected to analysis of variance using General Linear Model procedures of SAS statistical software (SAS Institute, 1999) and treatment means were compared by Least Significant Difference Test at P<0.05 statistical level.

Results and Discussion

As shown in Table 1, the highest egg production allotted to the birds fed on Ca-P-sufficient diets supplemented with calcitriol. There was a significant (P<0.05) interaction between
dietary Ca-P level and vitamin source in the light of egg production percentage so that, decrease in dietary Ca-P level was associated with higher decrease in egg production in calcitriol-supplemented diets than with D3-supplemented ones. Regardless of dietary Ca-P level, the best feed conversion ratios assigned to the calcitriol-supplemented birds. Consistent with these observations, Jahanian (2011) reported that the chicks from calcitriol-fed breeders had (P<0.05) the better weight gain and feed intake compared with those hatched from D3-fed breeders.

Table 1. Influence of vitamin D source on performance parameters of laying hens fed on Ca/P-sufficient or –deficient diets

<table>
<thead>
<tr>
<th>Vitamin D source</th>
<th>Dietary Ca/P level</th>
<th>Egg production (%)</th>
<th>Egg weight (g)</th>
<th>Egg mass (g/d per bird)</th>
<th>Feed intake (g/d per bird)</th>
<th>FCR (g feed/ g egg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3</td>
<td>Normal</td>
<td>71.22</td>
<td>64.16</td>
<td>45.68</td>
<td>114.45</td>
<td>2.51</td>
</tr>
<tr>
<td></td>
<td>20%-deficient</td>
<td>70.92</td>
<td>63.29</td>
<td>45.09</td>
<td>113.77</td>
<td>2.55</td>
</tr>
<tr>
<td>Calcitriol</td>
<td>Normal</td>
<td>75.17</td>
<td>62.55</td>
<td>47.02</td>
<td>111.73</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>20%-deficient</td>
<td>72.07</td>
<td>63.76</td>
<td>45.97</td>
<td>113.56</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Probability:
- NS: not significant; *P<0.05; **P<0.01.

Dietary supplementation with calcitriol increased tibial Ca (P<0.01) and P (P<0.05) contents and the least concentration (P<0.05) of tibial Ca was observed in hens fed on Ca-P-deficient diets (Table 2). Jahanian (2011) with study on chicks hatched from broiler breeder hens fed on D3- or calcitriol-supplemented diets reported that chicks from D3-breeders had lower tibia Ca and ash when fed with deficient diet than their counterparts of calcitriol-breeders.

Table 2. Influence of vitamin D source on tibial mineral content (%) of laying hens fed on Ca/P-sufficient or –deficient diets

<table>
<thead>
<tr>
<th>Vitamin D source</th>
<th>Dietary Ca/P level</th>
<th>Ash</th>
<th>Calcium</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3</td>
<td>Normal</td>
<td>52.38</td>
<td>17.63</td>
<td>8.36</td>
</tr>
<tr>
<td></td>
<td>20%-deficient</td>
<td>49.63</td>
<td>16.74</td>
<td>7.02</td>
</tr>
<tr>
<td>Calcitriol</td>
<td>Normal</td>
<td>54.01</td>
<td>18.29</td>
<td>8.23</td>
</tr>
<tr>
<td></td>
<td>20%-deficient</td>
<td>50.76</td>
<td>16.59</td>
<td>7.89</td>
</tr>
</tbody>
</table>

Probability:
- **: P<0.01; *: P<0.05
- NS: not significant.

NS: not significant; *P<0.05; **P<0.01.
In addition, Edwards (1989) showed that the addition of 1,25-(OH)2D3 had a significant effect on the absorption and retention of 47Ca. The same researcher hypothesized that the supplemental 1,25-(OH)2D3 may exert a direct effect on cartilage development and differentiation or bone mineralization, since 1,25-(OH)2D3 is concentrated in osteoblasts and osteoprogenitor cells (preosteoblasts) which synthesize collagen (Edwards, 1989). Data on ileal nutrient digestibility is presented in Table 3. As noted, dietary treatments had significant (P<0.05) impacts on ileal digestibility coefficients of dry matter, Ca and ash; however, P and crude protein digestibilities weren't influenced by dietary Ca-P level or vitamin source. Reports show that the active metabolite of vitamin D3, 1,25-dihydroxycholecalciferol, is involved in Ca and P absorption in the gut, bone mineralization (bone formation) and demineralization (bone mobilization), and Ca and phosphate resorption by the kidney (Combs, 1998). Therefore, the fact that calcitriol supplementation of diets could alleviate the problems resulted from Ca/P deficiency, isn’t unexpected.

![Table 3. Effect of vitamin D source on ileal nutrient digestibility (%) of laying hens fed on Ca/P-sufficient or –deficient diets](image)

The present observations indicate that calcitriol supplementation of laying diets could improve overall performance and bone mineralization. It seems that calcitriol could compensate for a part of problems related to Ca/P deficient diets in laying hens.

**References**


JAHANIAN, R., 2011: Calcitriol supplementation of broiler breeders' rations alleviates calcium and phosphorus deficiency in their progenies. 18th European Symposium on Poultry Nutrition. October 31-November 04, Çeşme, Izmir, Turkey, 465-467.


