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Effects of Dietary Modifications on Laying Hens in High-Rise Houses: Part II—Hen Production Performance

Stacey Ann Roberts
Iowa State University

Hong Li
Iowa State University

Hongwei Xin
Iowa State University, hxin@iastate.edu

Robert T. Burns
Iowa State University

Kristjan Bregendahl
Iowa State University

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Abstract
Dietary manipulation can substantially lower ammonia emissions from laying hen manure. However, such dietary changes would be of little value if the changes cause inferior egg production and hen performance. Therefore, the objective of this study was to evaluate the effect of a diet containing EcoCalTM (gypsum and zeolite), which has been shown to lower ammonia emission in laboratory-scale testing, on hen production performance in commercial high-rise laying hen houses. A companion paper describes the effect of the EcoCal diet on ammonia, hydrogen sulfide, and carbon dioxide emissions. Two high-rise houses, each containing approximately 255,000 hens, were used for the study. Hens in one house were fed a diet containing 3.5% EcoCal, whereas hens in the other house were fed an EcoCal-free, control diet. The cooperating farm provided the production records. The comparative production data have been collected since October 2006 and the study is scheduled to continue for another 2 years (i.e., through 2009). The period was broken into 2-wk increments for data analyses. Feed consumption was higher for the EcoCal-fed hens from 100 to 105 weeks of age. Egg production was transiently lower for the EcoCal-fed hens during the 92 to 93 wk-of-age period and egg weight was lower during the 96 to 97 wk-of-age period. Consequently, egg mass was lower during both the 92 to 93 and 96 to 97 wk-of-age periods. Feed conversion was more favorable for the control-fed hens from 100 to 103 wk of age. Mortality was lower for the EcoCal-fed hens from 92 to 93 and 100 to 105 wk of age. Results from December 2006 through May 2007 presented in this paper show mostly transient differences in production parameters between the dietary regimens. Future analyses will help better determine or affirm the effects of the EcoCal diet.

Keywords
Dietary modification, Ammonia, Laying hen

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Effects of Dietary Modifications on Laying Hens in High-Rise Houses: Part II—Hen Production Performance

S. A. Roberts, H. Li, H. Xin, R. T. Burns, and K. Bregendahl

Iowa State University

Abstract. *Dietary manipulation can substantially lower ammonia emissions from laying hen manure. However, such dietary changes would be of little value if the changes cause inferior egg production and hen performance. Therefore, the objective of this study was to evaluate the effect of a diet containing EcoCal™ (gypsum and zeolite), which has been shown to lower ammonia emission in laboratory-scale testing, on hen production performance in commercial high-rise laying hen houses. A companion paper describes the effect of the EcoCal diet on ammonia, hydrogen sulfide, and carbon dioxide emissions. Two high-rise houses, each containing approximately 255,000 hens, were used for the study. Hens in one house were fed a diet containing 3.5% EcoCal, whereas hens in the other house were fed an EcoCal-free, control diet. The cooperating farm provided the production records. The comparative production data have been collected since October 2006 and the study is scheduled to continue for another 2 years (i.e., through 2009). The period was broken into 2-wk increments for data analyses. Feed consumption was higher for the EcoCal-fed hens from 100 to 105 weeks of age. Egg production was transiently lower for the EcoCal-fed hens during the 92 to 93 wk-of-age period and egg weight was lower during the 96 to 97 wk-of-age period. Consequently, egg mass was lower during both the 92 to 93 and 96 to 97 wk-of-age periods. Feed conversion was more favorable for the control-fed hens from 100 to 103 wk of age. Mortality was lower for the EcoCal-fed hens from 92 to 93 and 100 to 105 wk of age. Results from December 2006 through May 2007 presented in this paper show mostly transient differences in production parameters between the dietary regimens. Future analyses will help better determine or affirm the effects of the EcoCal diet.*

Keywords. *Dietary modification, Ammonia, Laying hen*

Introduction

Ammonia (NH_3) is a major aerial pollutant emitting from livestock operations and from poultry manure in particular. Not only does ammonia contribute to nuisance odors, it contributes to acid rain and eutrophication of surface waters (Miles et al., 2004; Ritz et al., 2004). Therefore, minimizing ammonia emission from laying-hen facilities is of socio-economic importance to modern egg producers. Several options are available to lower ammonia emission from poultry manure but some are more feasible than others. Post-excretion mitigation techniques include chemical or physical treatment of the manure. An example of a chemical treatment would be acidification of the manure to trap NH_3 as the ammonium ion (NH_4^+), which is less volatile. Physical treatments to lower ammonia emission include minimizing the surface area of the manure pile (Li, 2006) or lowering the moisture content (Yang et al., 2000). Another ammonia-lowering method is dietary manipulation. Dietary treatments, such as lowering the protein content, including high-fiber ingredients, or including EcoCal in the diet have been shown to lower ammonia emission (Liang et al., 2005; Roberts et al., 2007; Wu-Haan et al., 2007). EcoCal is a proprietary mixture of gypsum (calcium sulfate) and zeolite designed for inclusion in the laying-hen diet. The calcium sulfate is included as an acidifier to lower the pH of the manure and the zeolite is included as a binder to trap the ammonium nitrogen, thereby decreasing volatilization. The objectives of this field research were two-fold: a) to quantify the efficacy of the EcoCal diet, as compared to the control diet, with regards to ammonia emission from commercial high-rise laying-hen houses; and b) to determine the impact of the EcoCal diet on egg production of the hens, as compared to control diet. This report describes the production performance of the hens.

Materials and Methods

Two commercial high-rise houses, each containing approximately 255,000 white leghorn (Hy-Line W-36) laying hens, were used for this research. Hens in one house were fed a diet that contained 3.5% EcoCal, while hens in the other house were fed a control diet, which did not contain EcoCal. All other ingredients were included in the proprietary commercial diet to supply nutrients to meet or exceed the NRC (1994) recommendations. Production performance was measured by staff at the farm and reported to the research group weekly. Egg production was measured using a laser beam counter placed across the egg belt at the end of each house. The total number of eggs was measured each day and divided by the house population, adjusted daily for mortality, to determine the percent egg production, then averaged by week. Each week, a representative case (30 dozens) of eggs were collected from each house and weighed. Individual egg weight

was subsequently calculated and expressed as grams per egg. Egg mass was calculated as egg production multiplied by egg weight to show the daily egg output per hen. Mortalities were recorded daily and house population was calculated by subtracting each week's mortalities. Feed consumption was measured as feed disappearance from the two bins per house and expressed as grams of feed consumed per hen daily. Hen body weight was determined once per month by weighing 100 hens in each house. The same 100 hens were weighed each month. Air temperature was recorded at hen level at the 3rd of 5 tiers in each house and averaged by week.

Hens fed the control diet were 9 weeks older than hens fed the EcoCal diet; therefore all data in this report are compared by hen age rather than by date. Data shown are from hens at 90 to 105 weeks of age, which corresponds to December 1, 2006 to March 22, 2007 for the control-fed hens and February 1, 2007 to May 24, 2007 for the EcoCal-fed hens.

Statistical analyses were performed using JMP (version 6.0, SAS Institute, Inc., Cary, NC). Data were analyzed using a separate ANOVA analysis for each 2-wk period with each week considered an observation; *P*-values ≤ 0.05 were considered significant. The model included the effect of treatment: EcoCal or control. Because hen weight was measured once per month rather than once per week, data were analyzed over the entire 16-wk period.

Results and Discussion

Because the 2-wk periods were not from the same calendar month for the two treatments, house temperature was measured and compared to determine if differences in production, if any, could have been due to temperature differences. House temperature is shown in each of Figures 1 to 6. The collection periods did not coincide with the warm summer season, hence there were no drastic temperature discrepancies observed. When hens were 90 to 91 and 104 to 105 wk of age, the temperature was 1.7 and 1.2ºC higher, respectively, in the EcoCal house compared to the control house. When the hens were 94 to 95 wk and 98 to 99 wk of age, it was 1.2ºC lower in the EcoCal house compared to the control house.

Feed consumption is shown in Figure 1. Hens in the EcoCal regimen consumed 8.5, 8.5, and 9.2 g/d more feed than hens in the control regimen for the periods of 100 to 101, 102 to 103, and 104 to 105 wk of age, respectively. Environmental temperature may affect feed consumption with lower temperatures causing higher feed consumption and vice versa (Leeson and Summers, 2005). However, of the three periods where feed consumption was greater for the EcoCal-fed hens, house temperatures were only different for the final period (104 to 105 wk of age). Furthermore, air temperature was higher in the EcoCal house compared to the control house, which would have led to a lower feed consumption rather than the higher consumption that was observed. The greater feed consumption of the EcoCal hens at higher house temperature indicates that temperature was likely not the cause of the differences in feed intake between the dietary regimens.

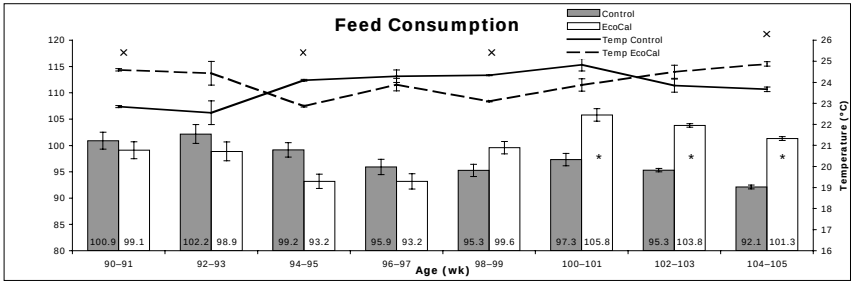

Figure 1. Bi-weekly mean house temperature and daily feed consumption of laying hens fed either a diet containing 3.5% EcoCal or a control diet containing 0% EcoCal. [× denotes significant difference in house temperature ($P \leq 0.05$); * denotes significant difference in feed consumption ($P \leq 0.05$) between the EcoCal and control dietary regimens.]

Egg production is shown in Figure 2. Egg production was transiently lower from the EcoCal-fed hens during 92 to 93 wk of age but was not different during the remainder of the observation periods. Egg weight and egg mass are shown in Figures 3 and 4, respectively. Egg weight was 0.6 g lower for the EcoCal-fed hens during 96 to 97 wk of age. However, egg weight was numerically greater during the following period, indicating there were no long-lasting problems with egg weight. Egg mass was 2.8 g/d and 1.2 g/d lower from the EcoCal-fed hens compared to the control for 92 to 93 wk of age and 96 to 97 wk of age, respectively. The lower egg mass during 92 to 93 wk of age was due to the lower egg production (Fig. 2)

during that time whereas the lower egg mass during 96 to 97 wk of age was due to the lower egg weight (Fig. 3) during that period.

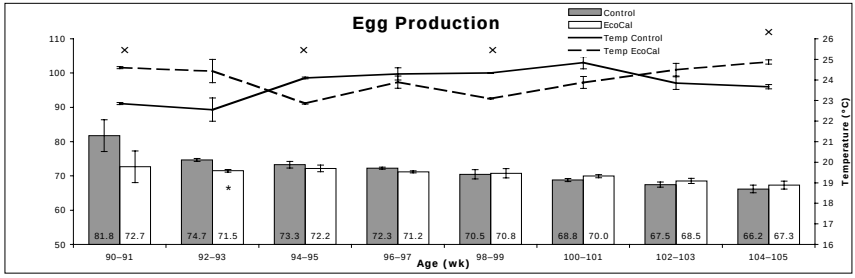

Figure 2. Bi-weekly mean house temperature and egg production of laying hens fed either a diet containing 3.5% EcoCal or a control diet containing 0% EcoCal. [× denotes significant difference in house temperature ($P \leq 0.05$) between the EcoCal and control dietary regimens.]

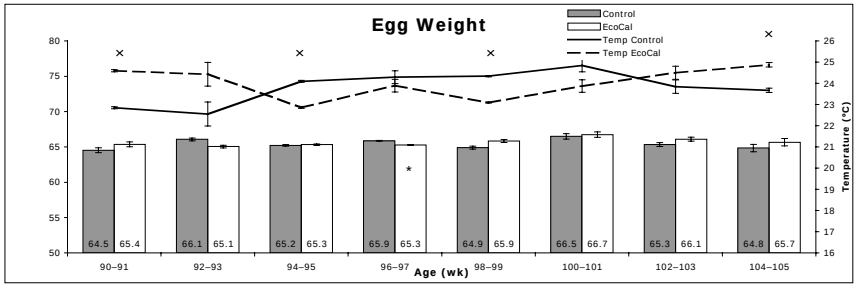

Figure 3. Bi-weekly mean house temperature and egg weight of laying hens fed either a diet containing 3.5% EcoCal or a control diet containing 0% EcoCal. [× denotes significant difference in house temperature ($P \leq 0.05$) between the EcoCal and control dietary regimens.]

Feed conversion (FC) was calculated as units (e.g., grams) of feed per unit (e.g. gram) of egg mass and is shown in Figure 4. There were no differences in FC when hens were 90 to 99 and 104 to 105 wk of age; however, during 100 to 101 and 102 to 103 wks of age, the control-fed hens had a better FC than the EcoCal-fed hens. The difference in FC was due mainly to the greater feed consumption (Fig. 1), as egg mass (Fig. 5) was not different.

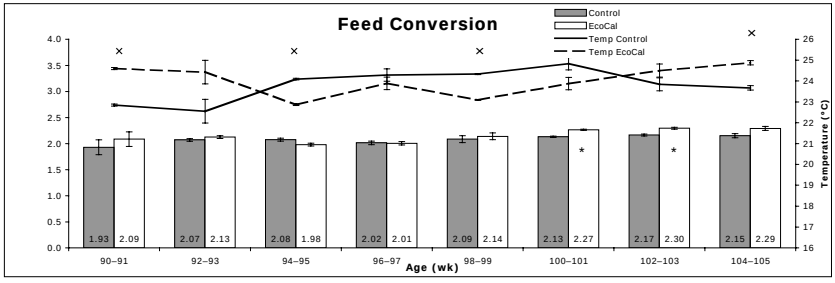

Figure 4. Bi-weekly mean house temperature and feed conversion of laying hens fed either a diet containing 3.5% EcoCal or a control diet containing 0% EcoCal. [× denotes significant difference in house temperature ($P \leq 0.05$). * denotes significant difference in feed conversion ($P \leq 0.05$) between the EcoCal and control dietary regimens.]

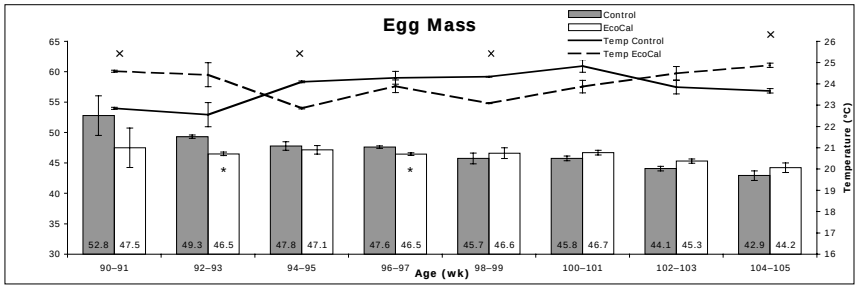

Figure 5. Bi-weekly mean house temperature and egg mass of laying hens fed either a diet containing 3.5% EcoCal or a control diet containing 0% EcoCal. [× denotes significant difference in house temperature ($P \leq 0.05$) between the EcoCal and control dietary regimens.]

The monthly body weight (BW) measurements were analyzed for the entire 16-wk period. The mean BW over this period was 1.74 and 1.64 ±0.01 kg ($P < 0.0001$) for the EcoCal and control diets, respectively. At the onset of the data analysis period when hens were 90 wk of age, the mean BW of the EcoCal-fed hens was 1.67 kg while the control hens weighed 1.63 kg. At the end of the data analysis period, the EcoCal hens weighed 1.75 kg while the mean BW of the control-fed hens was 1.63 kg. This indicates that the EcoCal hens were gaining weight at a faster rate (80 g weight gain over the 16-wk period) than the control hens (0 g weight gain). The EcoCal hens also consumed more feed during the last 8 wk of the 16-wk data analysis period. The increased feed consumption may have led to the larger body weight for the EcoCal hens. The greater body weight would in turn require somewhat higher energy intake for metabolic maintenance. Mortality, expressed as percentage per week, is shown in Figure 6. During the period of 92 to 93 wk and 100 to 105 wk the control flock experienced a higher mortality compared to the EcoCal. However, it is difficult to say with certainty if the differences in the observed flock mortality were linked to the dietary treatment. Further test data are expected to help elucidate this potential linkage.

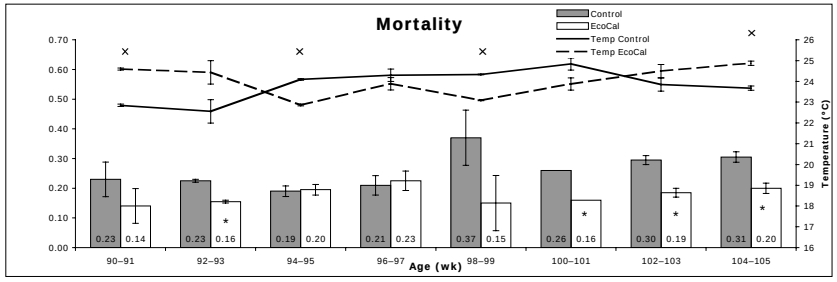

Figure 6. Bi-weekly mean house temperature and flock mortality of laying hens fed either a diet containing 3.5% EcoCal or a control diet containing 0% EcoCal. [× denotes significant difference in house temperature ($P \leq 0.05$); * denotes significant difference in mortality rate ($P \leq 0.05$) between the EcoCal and control dietary regimens.]

Conclusion

Dietary manipulations are a potential means to mitigate ammonia emission from laying-hen facilities. Dietary EcoCal was evaluated for its efficacy as an ammonia-lowering feed ingredient in a commercial egg-production operation (reported in a separate paper) and its effects on hen production performance. Data to date show few differences in egg production, egg weight, or egg mass (output) for hens fed 3.5% EcoCal compared to hens fed a control (EcoCal-free) diet. Compared with the control hens, the EcoCal hens consumed more feed and had a lower mortality rate during 100 to 105 wk of age, and had a less favorable feed conversion during 100 to 103 wk of age. Additionally, the EcoCal hens tended to have a larger body weight. This research is ongoing, and future analyses should help better determine if the observed differences were due to the dietary treatment.

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