Effects of a Pre-Molt Calcium and Low-Energy Molt Program on Laying Hen Physiology

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Summary and Implications

The objectives of this study were to compare stress measures and bone quality of laying hens when offered a Ca pre-molt treatment followed by low-energy molt diets versus a traditional feed withdrawal before, during, and after an induced molt. A total of 189 Hy-Line W-36 laying hens (85 wk of age, 1.7 ± 0.2 kg), housed 3 per cage, (413 cm^2/hen) were used. Six treatments were compared in a 2 × 3 factorial design with 2 Ca (coarse and fine) pre-molt treatments (coarse and fine) and 3 molt diets: feed withdrawal (FW), soybean hulls (SH), and wheat middlings (WM). The Ca pre-molt treatment was defined as the period when the hens received either a combination of fine (0.14 mm in diameter) and coarse (2.27 mm in diameter) $CaCO_3$ or an all-fine $CaCO_3$ mixed into a commercial diet for 1 wk. Both diets were formulated to contain 4.6% Ca, such that only the particle size of the $CaCO_3$ differed between the 2 treatments. Hens had free access to feed and water and had a 24-h photoperiod. The 3 molt diets were applied for a total of 28 d. The hens assigned to the FW molt diet were deprived of feed for 7 d with free access to water followed by 21 d of skip-a-day feeding restricted to 60 g of feed / hen per feeding day. The hens fed the WM and SH molt diets were provided free access to feed and water during the entire 28 d molt period. Lighting was reduced to 8 h for the first 3 wk and was then increased to 12 h at the start of the last week of molt. During the 22 wk post-molt, hens were fed a laying hen diet and lighting was increased by 1 h each week to 16 h. None of the treatments resulted in an increased heterophil to lymphocyte ratio during or post-molt compared to baseline values, which would have suggested increased stress in the laying hen. Additionally, any changes reported during molt in bone quality returned to baseline values during the post-molt period. Therefore, these treatments are acceptable for inducing molt in the laying hen.

Introduction

In commercial laying hens, molt is induced to allow for a second laying cycle, extending the productive life of the hen. During molt, egg production ceases and the reproductive tract regresses. Molt has been traditionally induced by a period of feed withdrawal (FW). However, this practice has recently raised concern for the well-being of the laying hen. In addition, industry groups have recommended that after January 1, 2006, producers implement only non-fasting molt programs. Previous research has reported the effectiveness of low-energy diets as alternatives to FW for inducing molt. In addition, a diet severely deficient in Ca has also been used to induce molt. The form of Ca is also important with particulates (coarse Ca) solubilized more slowly from the digestive tract compared to powdered Ca (fine Ca). The coarse Ca may provide the hen with more Ca for use in eggshell and bone formation. Therefore, a fine-Ca pre-molt treatment may result in a more efficient molt and its possible effects on stress and bone quality were examined. The objectives of this study were to compare stress measures and bone quality of laying hens when offered a Ca pre-molt treatment followed by low-energy molt diets versus a traditional FW before, during, and after an induced molt.

Materials and Methods

Animals and Location: A total of 189 Hy-Line W-36 laying hens (85 wk of age), weighing 1.7 ± 0.2 kg, were used in this study. Research was conducted over 29 wk from July 2007 to February 2008 at the Iowa State University Poultry Research Center in Ames, IA. The project was approved by the Iowa State University Animal Care and Use Committee.

Diets, Housing and Husbandry: Laying hens were housed 3 per cage (30.5 cm wide × 40.6 cm deep × 44.5 cm high), providing 413 cm^2/hen. Wire flooring was used in all cages and each cage was equipped with a plastic self-feeder and a nipple drinker. All cages were located in 2 identical, light-controlled fan-ventilated rooms.

Treatments: Six treatments were compared in a 2 × 3 factorial arrangement with 2 Ca (fine and coarse) pre-molt treatments and 3 molt diets: FW, soybean hulls (SH), and wheat middlings (WM). The Ca pre-molt treatment was defined as the period when the hens received either a combination of fine (0.14 mm in diameter) and coarse (2.27 mm in diameter) $CaCO_3$ or an all-fine $CaCO_3$ mixed into a commercial diet for 1 wk. Both diets were formulated to contain 4.6% Ca, such that only the particle size of the $CaCO_3$ differed between the 2 treatments. Hens had free access to feed and water and had a 24-h photoperiod. The 3 molt diets were applied for a total of

28 d. The hens assigned to the FW molt diet were deprived of feed for 7 d with free access to water followed by 21 d of skip-a-day feeding restricted to 60 g of feed/hen per feeding day. The hens fed the WM and SH molt diets were given free access to feed and water during the entire 28 d molt period. Lighting was reduced to 8 h for the first 3 wk and was then increased to 12 h at the start of the last week of molt. During the 22 wk after molt, hens were provided with laying hen diets. This period was divided into the first 2 wk after molt and the following 20 wk according to diet recommendations from the 2007–2008 Hy-Line W-36 commercial management guide. Hens were given free access to feed and water and the lighting was increased by 1 h each week until reaching a 16 h photoperiod.

Physiologic Parameters: Blood was collected from each hen at the end of the baseline period (9 hens), at the end of the Ca pre-molt treatment (9 hens from each of the 2 treatments), during the middle and end of the molt period (9 hens from each of the 6 treatments), and at the end of the post-molt period (9 hens from each of the 6 treatments). Blood smears were made for the heterophil to lymphocyte (H:L) ratio. The remaining blood was centrifuged and the plasma was collected for analysis of plasma Ca and inorganic P concentrations and alkaline phosphatase activity (ALP). After blood was collected, all hens were euthanized by CO_2 asphyxiation. Fresh weights of ovaries and oviducts were recorded and eggs in the reproductive tract, if any, were removed before weighing. The left-side humerus and femur bones were used to determine bone mineral content. Ash content was expressed as a percentage of the dry bone weight.

Statistical Analysis: The experimental design was a randomized complete block design with treatments in a 2 × 3 factorial arrangement with 2 Ca pre-molt treatments and 3 molt diets. The experimental unit was the individual hen (n = 189). The baseline model included treatment and block (based on initial body weight and cage location within the barn; 1 to 11). During the Ca pre-molt treatment, Ca treatment and block were used in the model. During and post-molt, the model included Ca pre-molt treatment, molt diet, the 2-way interaction of these, and block. The effect of the Ca pre-molt treatment was assessed using the main effect of the Ca treatment from the ANOVA table, whereas the effect of the molt diet was assessed by Fisher's least significant difference. Experimental values were compared to baseline values using Dunnett's test. A $P < 0.05$ was considered significant.

Results and Discussion

Pre-molt calcium treatment: Hens fed the coarse-Ca pre-molt treatment had higher ovary and oviduct weights compared to hens during the baseline period ($P < 0.05$). Hens fed the fine-Ca pre-molt treatment had lower humerus-ash percentages and higher plasma inorganic P concentrations compared to hens during the baseline period ($P < 0.05$). There were no differences between the 2 treatments for any of the measures ($P > 0.05$; Tables 1 and 2).

During molt: Hens assigned to the 6 treatments had lower ovary and oviduct weights and plasma Ca concentrations, and higher ALP activity compared to hens during the baseline period ($P < 0.05$). There were no differences ($P > 0.05$) between baseline values and Ca pre-molt treatment values in H:L ratios, humerus-ash percentages, or plasma inorganic P concentrations (Tables 1 and 2). When comparing hens fed the 2 Ca pre-molt treatments, there were no differences in any of the measures ($P > 0.05$). Hens fed the FW and WM molt diets had lower femur-ash percentages compared to hens during the baseline period. When comparing hens fed the 3 molt diets, hens fed the WM molt diet had higher ovary weights compared to hens fed the SH molt diet and higher oviduct weights and plasma Ca concentrations compared to hens assigned to the other 2 molt diets ($P < 0.05$). However, there were no differences in bone-ash percentages, H:L ratios, plasma inorganic P concentrations, or ALP activity ($P > 0.05$; Tables 1 and 2).

Post-molt: Hens assigned to the Ca pre-molt treatments had no differences compared to hens from the baseline period in ovary weights, bone-ash percentages, H:L ratios, plasma Ca, or inorganic P concentrations ($P > 0.05$). However, hens fed the fine-Ca pre-molt treatment had higher ALP activity compared to hens during the baseline period and higher oviduct weights compared to the baseline period and to the coarse-Ca pre-molt treatment ($P < 0.05$). Hens fed the molt diets had no differences compared to hens from the baseline period in ovary and oviduct weights, bone-ash percentages, H:L ratios, plasma Ca, or inorganic P concentrations ($P < 0.05$). Hens fed the SH molt diet had higher ALP activity compared to hens during the baseline period, but there were no differences in any of the measures among the 3 molt diets (Tables 1 and 2).

Conclusions: The fine-Ca pre-molt treatment did not negatively affect bone quality of the laying hen and did not result in an increased H:L ratio compared to baseline values, which would have suggested a stress effect on the laying hen. The 3 molt diets also had no detrimental effects on stress and bone quality of the laying hen. Any differences that were reported during molt returned to baseline values during the post-molt period. Therefore, these treatments are acceptable for use during an induced molt in the laying hen.

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Table 1. Comparison of responses of hens during each period for reproductive tract weights and bone ash-percentages[1]

		Treatments							
		Calcium pre-molt[2]		Molt[3]				*P*-values[4]	
Measures	**Baseline**	**Coarse**	**Fine**	**FW**	**SH**	**WM**	**SEM**	**Ca**	**Molt**
Ovary, g	41.3	–	–	–	–	–	1.95	–	–
Calcium pre-molt		50.9*	49.3	–	–	–	3.16	0.73	–
During molt		5.92*	5.60*	5.27*,[ab]	4.51*,[a]	7.50*,[b]	1.66	0.74	0.03
Post-molt		42.3	48.3	45.8	42.9	47.3	3.62	0.06	0.49
Oviduct, g	52.1	–	–	–	–	–	5.19	–	–
Calcium pre-molt		66.4*	64.4	–	–	–	3.10	0.67	–
During molt		13.2*	12.2*	10.9*,[a]	11.0*,[a]	16.2*,[b]	3.08	0.60	0.02
Post-molt		52.4	65.4*	61.2	55.1	60.3	4.09	0.001	0.31
Humerus bone, %	64.6	–	–	–	–	–	0.68	–	–
Calcium pre-molt		62.0	61.0*	–	–	–	3.43	0.52	–
During molt		61.0	61.7	61.7	60.8	61.7	0.96	0.36	0.56
Post-molt		62.2	61.5	61.7	61.6	62.3	1.50	0.85	0.57
Femur bone, %	55.2	–	–	–	–	–	1.42	–	–
Calcium pre-molt		55.1	54.6	–	–	–	1.02	0.75	–
During molt		51.5*	50.5*	50.9*	51.7	50.3*	1.06	0.22	0.39
Post-molt		52.9	53.3	53.2	52.5	53.6	1.55	0.72	0.79

[1]Values are least squares means ± pooled SEM (n = 9).
[2]Calcium was supplied as a 50:50 mix of fine (0.14 mm mean diameter) and coarse (2.27 mm mean diameter) $CaCO_3$ or as an all-fine $CaCO_3$ mixed into a laying hen diet for a 1 wk pre-molt Ca treatment.
[3]Three molt diets were compared: feed withdrawal (FW), soybean hulls (SH), and wheat middlings (WM).
[4]*P*-values from main effect of Ca pre-molt treatment or molt diet.
[a,b]Means within a row lacking a common superscript differ ($P < 0.05$).
*Means within a row differ from baseline value ($P < 0.05$). *P*-value from Dunnett's comparison.

Table 2. Comparison of responses of hens during each period for the blood measures[1]

		Treatments							
		Calcium pre-molt[2]		Molt[3]				*P*-values[4]	
Measures	**Baseline**	**Coarse**	**Fine**	**FW**	**SH**	**WM**	**SEM**	**Ca**	**Molt**
H:L ratio, %	40	–	–	–	–	–	0.04	–	–
Calcium pre-molt		45	41	–	–	–	0.09	0.59	–
During molt		42	46	42	44	46	0.04	0.36	0.59
Post-molt		47	40	46	43	41	0.04	0.01	0.42
Plasma Ca, mg/dL	29.6	–	–	–	–	–	2.27	–	–
Calcium pre-molt		33.1	35.0	–	–	–	4.27	0.58	–
During molt		13.7*	12.2*	11.4*[a]	11.3*[a]	16.2*[b]	2.06	0.39	0.03
Post-molt		31.5	32.3	32.2	33.8	29.5	1.74	0.61	0.06
Inorganic P, mg/dL	1.15	–	–	–	–	–	0.08	–	–
Calcium pre-molt		1.42	1.48*	–	–	–	0.08	0.58	–
During molt		1.06	1.01	0.96	1.07	1.09	0.05	0.36	0.16
Post-molt		1.32	1.36	1.33	1.41	1.23	0.10	0.42	0.64
Alkaline phosphatase, IU/L	32.4	–	–	–	–	–	5.04	–	–
Calcium pre-molt		32.4	58.0	–	–	–	9.60	0.58	–
During molt		71.6*	65.5*	62.2*	66.0*	77.4*	8.77	0.40	0.21
Post-molt		41.4	48.5*	45.0	50.4*	39.3	5.48	0.12	0.14

[1]Values are least squares means ± pooled SEM (n = 9).
[2]Calcium was supplied as a 50:50 mix of fine (0.14 mm mean diameter) and coarse (2.27 mm mean diameter) $CaCO_3$ or as an all-fine $CaCO_3$ mixed into a laying hen diet for a 1 wk pre-molt Ca treatment.
[3]Three molt diets were compared: feed withdrawal (FW), soybean hulls (SH), and wheat middlings (WM).
[4]*P*-values from main effect of Ca pre-molt treatment or molt diet.
[ab]Means within a row lacking a common superscript differ ($P < 0.05$).
[*]Means within a row differ from baseline value ($P < 0.05$). *P*-value from Dunnett's comparison.