EVALUATION OF NON-FEED VS FEED WITHDRAWAL METHODS FOR INDUCED MOLTING OF LAYING HENS

A Report Submitted to the United Egg Producers and Ridley Feed Ingredients

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INTRODUCTION

Concern for the welfare of the hen during an induced molt has been expressed by animal activists groups, poultry scientists, and commercial poultrymen in recent years. Most commercial laying hen molting programs utilize some length of feed removal to initiate a molt. These practices have raised some questions and concerns by the general public regarding the practice of removing feed from laying hens to induce molting. In fact, the concern about this practice to initiate a molt in commercial layer flocks has been a topic of great discussion with industry groups.

The United Egg Producers (UEP) Scientific Advisory Committee on Animal Welfare and they made the recommendation to the UEP that researchers and producers work together to develop alternatives to feed withdrawal for molting. In addition, at a meeting of the UEP Animal Welfare Scientific Committee, McDonald's Corporation said they would require egg producers that supply their eggs (1% of total U.S. egg production) to use no longer than a 4-day feed withdrawal program to initiate a molt (Bell, 2000). McDonald's Corporation also released a press statement that they would stop buying eggs from producers who utilized molting programs that involved feed and water withdrawal in their production systems (Egg Industry, 2000).

There are several types of induced molting methods that are currently used in today=s commercial egg industry. Our research group has conducted and published many studies to evaluate various types of molt programs and nutritional modifications during the last 10 years (Castanon et al., 1990; Koelkebeck, et al., 1991; 1992; 1993a,b; 1999, 2000). Most of these programs involve the use of feed withdrawal (fasting) to produce a cessation of egg production. These programs recommend using fasting periods of varying lengths. For example, Brake and Carey (1983) recommended fasting a flock until they reached a target body weight loss. The length of fast in this program is usually at least 10 days and usually longer. Other molting programs that have involved the use of a short feed withdrawal period (4 to 5 days) have showed that egg performance results can be comparable to those achieved by a traditional feed removal program (Koelkebeck et al., 1992; Ruszler, 1996).

To our knowledge, there has been little work done and published on the effects of a non-feed removal molt program. Thus, we have conducted two experiments which were financially supported by the California Egg Commission and Ridley Feed Ingredients, Inc. (Experiment 1) and the UEP (Experiment 2). In the first study, we evaluated the effect of several non-feed removal methods in comparison to a short feed removal period and a conventional feed removal period on long-term postmolt laying hen performance. For the second ongoing study, we evaluated eight treatments including the use of wheat middlings, a corn diet, wheat middlings in combination with a corn diet, corn gluten feed, and distillers grain with solubles in comparison to a conventional 10-day feed withdrawal period. Thus, the purpose of both studies was to determine the effects of non-feed removal molting alternatives on long-term postmolt performance of laying hens.

MATERIALS AND METHODS

Experiment 1

In this experiment, Single Comb White Leghorn hens of the DeKalb White Strain (60 wk of age) were housed in a cage layer house of commercial design with water and feed provided for *ad libitum* consumption and exposed to a 17-h daily photoperiod prior to the start of the experiment. Prior to starting the experiment, all hens were weighed and allocated to each treatment group according to equal body weights. Seven replicate groups of 12 hens each (4 adjacent raised wire cages, 30 x 46 cm, containing 3 hens per cage, i.e., 72 sq in per hen) were randomly assigned to each treatment.

A total of 336 hens were randomly assigned to four treatments, which consisted of birds fed a high corn molt diet or high wheat middlings molt diet and birds deprived of feed for 4 or 10 days. At the start of the experiment (Day 1), feed was withdrawn from the groups designated to be deprived of feed for 4 or 10 days. The birds in the other two treatments were fed their respective diets. The two continuous fed molt diets consisted of a 95% corn diet and a 95% wheat middlings diet (Table 1). Both diets were supplemented with 4% limestone and 1% vitamins and minerals. On Day 5, the 4-day feed withdrawn hens were given *ad libitum* access to the corn molt diet. On Day 11, the 10-day feed withdrawn hens were fed the corn molt diet. The hens deprived of feed for 4 or 10 days were fed the corn molt diet at a rate of 54 g per hen per day (12 lbs. per 100 birds per day) for the first two days following feed withdrawal to minimize overconsumption and crop impaction, and then were given *ad libitum* access to this diet for 22 or 16 days, respectively. These hens were then provided *ad libitum* access to a 16% protein layer diet. The hens that were not deprived of feed were fed *ad libitum* the corn or wheat middlings molt diets for 28 days, then fed the 16% protein layer diet (Table 1). The total length of the experiment was 44 weeks (four weeks for the molt period and 40 weeks for the postmolt lay period).

TABLE 1. Composition of experimental molt diets and layer diet

Ingredients and analysis	Corn diet (%)	Wheat middlings diet (%)	Layer diet (%)
Ground yellow corn	94.70	0.00	68.70
Wheat middlings	0.00	95.35	0.00
Soybean meal (dehulled)	0.00	0.00	18.40
Limestone	4.00	4.00	8.50
Meat and bone meal	0.00	0.00	2.50
Dicalcium phosphate	0.65	0.00	1.25
Salt	0.30	0.30	0.30
Mineral mix[1]	0.15	0.15	0.15
Vitamin mix[2]	0.20	0.20	0.20
Calculated analysis[3]			
Crude protein	8.1	14.3	16.0
Metabolizable energy, kcal/kg	3,172	1,900	2,865
Calcium	1.7	1.6	3.8
Nonphytate phosphorus	0.20	0.28	0.45

[1]Provided per kilogram of diet: manganese, 75 mg from manganese oxide; iron, 75 mg from iron sulfate; zinc, 75 mg from zinc oxide; copper, 5 mg from copper sulfate; iodine, 0.75 mg from ethylene diamine dihydroiodide; selenium, 0.1 mg from sodium selenite.
[2]Provided per kilogram of diet: vitamin A from vitamin A acetate, 4,400 IU; cholecalciferol, 1,000 IU; vitamin E from α-tocopheryl acetate, 11 IU; vitamin B_{12}, 0.011 mg; riboflavin, 4.4 mg; d-pantothenic acid, 10 mg; niacin, 22 mg; menadione sodium bisulfite complex, 2.33 mg.
[3]Based on NRC (1994) feed composition tables.

On Day 1 (the initiation of feed withdrawal or feeding molt diets), the daily photoperiod was decreased to 10 h. On Day 24 and 31, the daily photoperiod was increased to 12 and 13 h, respectively, then increased 15 min per week for the next four weeks. For the next six weeks, the photoperiod was increased 30 min per week until a photoperiod of 17 h was reached.

Performance data was measured for 44 weeks following the initiation of feeding the molt diets or feed withdrawal. Egg production and mortality were recorded daily. Egg weight, and egg specific gravity (using the flotation method with NaCl solutions varying in specific gravity from 1.056 to 1.096 in .004 increments), were measured on all eggs produced on 2 consecutive days each week for egg weight, and Weeks 6, 7, and 8 then monthly for egg specific gravity. Egg mass was calculated for Weeks 6 to 44 using hen-day egg production and average egg weight. Feed consumption was measured weekly for the entire experiment and feed efficiency was calculated for Weeks 6 to 44. Body weights of hens deprived of feed for 4 days were measured on Day 4, then all hens were weighed on Day 10 and 28. The economic implications of each treatment was evaluated by computing egg income minus feed costs.

Experiment 2.

In this experiment 636 Single Comb White Leghorn hens of the DeKalb White Strain (69 weeks of age) were used. They were housed in the same facility as Experiment 1 and exposed to a 17-h daily photoperiod prior to the start of the experiment. Six replicate groups of 12 hens each (4 adjacent raised wire cages, 30 x 46 cm, containing 3 hens per cage, 72 sq. in. per hen) were randomly assigned to each treatment. Prior to the initiation of the experiment, all hens were weighed and allocated to each treatment group according to equal body weights.

At the start of the experiment (Day 1), feed was withdrawn from the groups designated to be deprived of feed for 10 days. The birds in the other six treatments were fed their respective diets immediately (corn diet, wheat middlings, corn gluten feed, corn distillers grains with solubles, Table 2). On Day 11, the 10-day feed withdrawn hens were fed a 16% protein corn-soybean meal molt or a 94% corn diet, then were given *ad libitum* access to this diet for 18 days (Table 2). The 16% protein molt diet is a very well balanced nutritional diet that will result in hens rapidly regaining their body weight and rapidly returning to egg production. The 10-day feed withdrawal and then feeding a 16% protein molt diet is a program used in many commercial operations. The hens that were not deprived of feed (Treatments 3-8) were fed *ad libitum* or free-choice their diets for 28 days. Hens on all treatments were fed a 16% protein layer diet after 28 days. The total length of the experiment lasted for 44 weeks (four weeks for the molt period and 40 weeks for the postmolt lay period).

TABLE 2. Composition of experimental molt diets and layer diet

Ingredients and Analysis	16% CP Corn-SBM	Corn	Wheat middlings	Corn gluten feed	Distiller's dried grains	71% WM: 23% corn	47% WM: 47% corn	Layer diet
	-----------	-----------	-----------	---------- (%) ----------	-----------	-----------	-----------	-----------
Corn	73.78	93.68	--	--	--	22.99	47.05	68.70
Wheat Midlings	--	--	94.34	--	--	71.25	47.00	--
Corn Gluten Feed	--	--	--	95.00	--	--	--	--
DDGS	--	--	--	--	94.46	--	--	--
Soybean Meal	20.10	--	--	--	--	--	--	18.40
Meat and Bone Meal	--	--	--	--	--	--	--	2.50
Limestone	4.62	4.67	4.87	4.20	4.84	4.96	4.87	8.50
Dical	0.80	--	0.38	0.10	--	0.10	0.38	1.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Mineral Mix[1]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin Mix[2]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Larvadex	0.05	0.05	0.05	0.05	0.05	0.05	0.05	--
Calculated Analysis[3]:								
Crude Protein	16.0	8.0	14.2	20.0	25.9	12.6	11.1	16.0
ME_n (kcal/kg)	2,962	3,138	1,887	1,663	2,343	2,195	2,516	2,865
Calcium	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.8
Available Phosphorus	0.25	0.25	0.28	0.25	0.37	0.25	0.25	0.45

[1]WM = wheat middlings.

[2]Provided per kilogram of diet: manganese, 75 mg; iron, 75 mg; zinc, 75 mg; copper, 5 mg; iodine, 0.75 mg; selenium, 0.1 mg.

[3]Provided per kilogram of diet: vitamin A from vitamin A acetate, 4,400 IU; cholecalciferol, 1,000 IU; vitamin E from α-tocopheryl acetate, 11 IU; vitamin B_{12}, 0.011; riboflavin, 4.4 mg; d-pantothenic acid, 10 mg; niacin, 22 mg; menadione sodium bisulfite complex, 2.33 mg.

Thus, the eight dietary molt treatments were as follows:

1. Fed a 94% corn diet continuously for 28 days
2. Fed a 94% wheat middlings diet continuously for 28 days
3. Fed a 47.0% wheat middlings:47.0% corn diet continuously for 28 days (50:50)
4. Fed a 71% wheat middlings:23% corn diet continuously for 28 days (75:25)
5. Fed a 95% corn gluten feed diet continuously for 28 days
6. Fed a 95% corn distillers grain with solubles diet continuously for 28 days
7. Feed withdrawn for 10 days, then fed a 16% protein corn-soybean meal molt diet for 18 days
8. Feed withdrawn for 10 days, then fed a 94% corn diet for 18 days

On Day 1 (the initiation of feed withdrawal or feeding molt diets), the daily photoperiod was decreased to 10 h. On Day 24 and 31, the daily photoperiod was increased to 12 and 13 h respectively, then increased 15 min per week until 17 h per day was achieved.

Ovarian Regression

It was of interest to determine the degree of ovarian regression among treatments, particularly for the hens not deprived of feed compared to the 10-day feed withdrawn hens. Total or almost total ovarian regression is needed to obtain good long-term egg production and egg shell quality during the second production cycle. Therefore, an additional group of 12 hens (four adjacent cages containing hens hens per cage) were allocated to Treatments 1, 3, 4, 7, and 8 (n=60). To determine the regression in ovary and oviduct weights, three hens from each group were euthanized on Day 1, 10, 21 and 28. Ovary and oviduct weights were recorded and the data is presented as a percentage of body weight.

Egg Production and Stress

Egg production performance was measured as previously described for Experiment 1. In addition, general physiological stress was determined by counting blood leukocytes and calculating the heterophil:lymphocyte ratio as described by McKee and Harrison (1995). An elevated ratio should indicate increased stress. Blood samples were obtained from the wing vein from one hen per replicate on Day 0, 10, and 28.

Statistical Analyses

All data were analyzed by analysis of variance procedures appropriate for a one-way completely randomized design with the Fisher's least significant difference test used to determine significant differences among treatment means (Steel and Torrie, 1980). For feed consumption during the molt period and postmolt lay period, data was recorded in g/hen/day, then extrapolated to lbs/100 hens/day.

RESULTS AND DISCUSSION

Experiment 1

The decrease in daily hen-day egg production during the 28-day molt period is graphically shown in Figure 1. Hens that were deprived of feed for 4 or 10 days went out of production by Day 5, and those fed the wheat middlings molt diet ceased egg production by Day 8. In contrast, hens which were fed the corn molt diet never went completely out of production, and were producing at a rate of 2.7% by Day 28 of the molt period. From Day 5 through 13, hens fed the corn molt diet produced significantly more eggs than those on the other three treatments. By Day 15, 12, and 23, hens fed the wheat middlings molt diet, deprived of feed for 4 or 10 days returned to egg production, respectively.

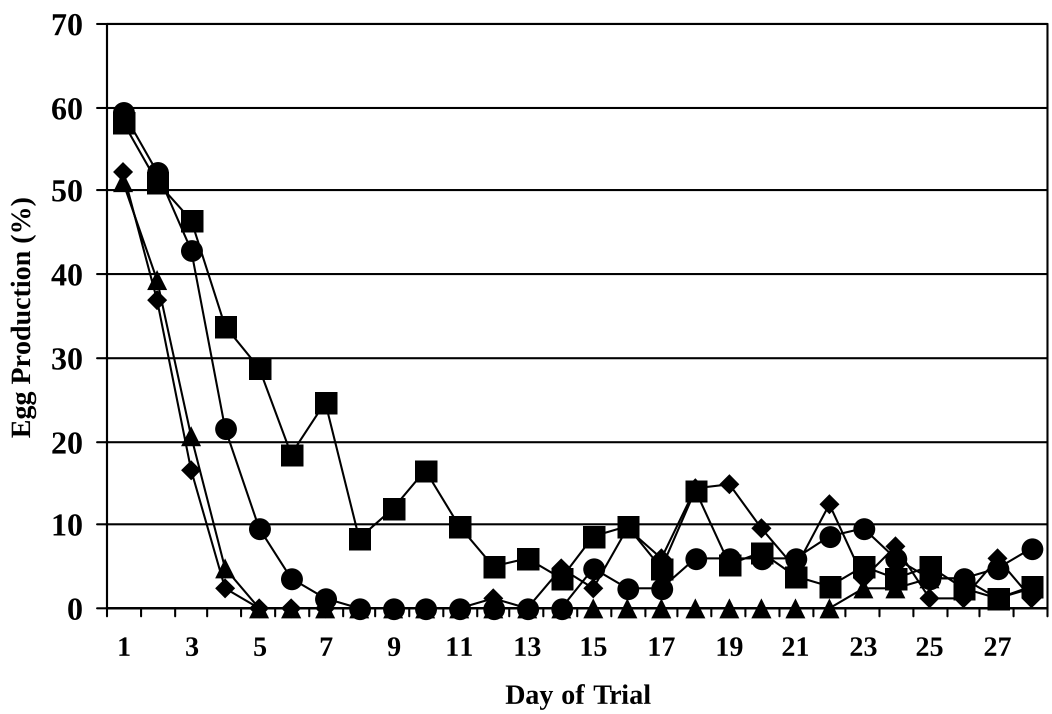

FIGURE 1. Hen-day egg production for Days 1 to 28. Treatment 1 (■) fed corn molt diet. Treatment 2 (●) fed wheat middlings diet. Treatment 3 (◆) feed withdrawn for 4 days. Treatment 4 (▲) feed withdrawn for 10 days.

The return to egg production after the initiation of feeding the layer diet is graphically shown in Figure 2 and summarized in Table 3. Postmolt egg production was generally higher for those hens fed the wheat middlings molt diet and 10-day feed removal treatments than for the corn and 4-day feed removal treatments. During Weeks 6 and 7 particularly, postmolt egg production was significantly higher for hens fed the wheat middlings molt diet than for hens fed the corn molt diet (Figure 2). Hens fed the wheat middlings molt diet reached 50% egg production the soonest with peak egg production being 89.6% and 90.7% for the 10-day feed removal treatment. Postmolt hen-day egg production was significantly greater for hens deprived of feed for 10 days compared to those fed the corn molt diet and deprived of feed for 4 days during Weeks 5 to 44 (Table 3). In addition, egg production was not significantly different for hens fed the wheat middlings molt diet and those deprived of feed for 10-days. There were no differences in postmolt mortality between any of the treatments during Weeks 5 to 44 (data not shown). These results indicate that postmolt egg production of hens fed the wheat middlings molt diet equaled that for hens that were deprived of feed for 10 days.

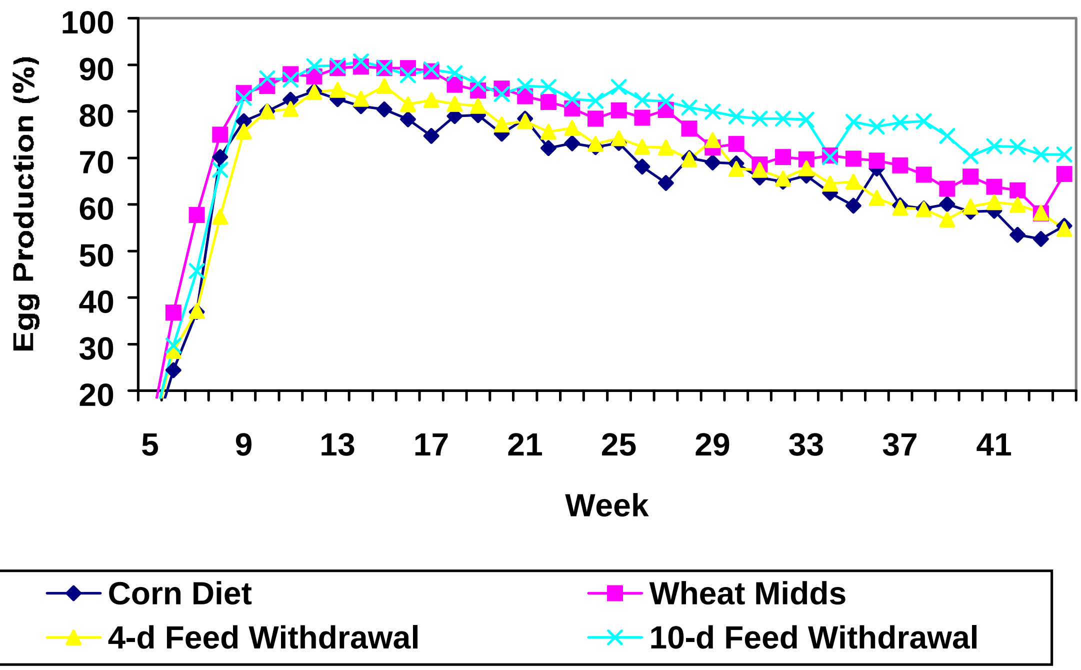

FIGURE 2. Hen-day Egg Production for Weeks 5-44

TABLE 3. Effect of non-feed vs feed removal molting methods on subsequent egg production

Treatment	Days to 50% production	Peak hen-day production	Egg Production (Wks 5-44)	Egg Production (Wks 1-44)
	(days)	(%) (wk)	-----------(% H-D)-------------	
Corn	49	84.3 (12)	66[b]	61[b]
Wheat midds	43	89.6 (14)	74[ab]	68[ab]
4-d removal, then corn	50	85.4 (15)	68[b]	62[ab]
10-d removal, then corn	47	90.7 (14)	77[a]	70[a]

[a,.b]Means within a column with no common superscript differ significantly ($P < .05$).

Figure 3 shows the cumulative hen-housed eggs per hen for Weeks 5 to 44. This shows that hens that were deprived of feed for 10 days produced the most hen-housed eggs per hen up to 44 weeks (207), followed by 202 eggs per hen for hens fed the wheat middlings molt diet. Hens that were deprived of feed for 4 days and those fed the corn diet produced 180 and 171 eggs per hen, respectively.

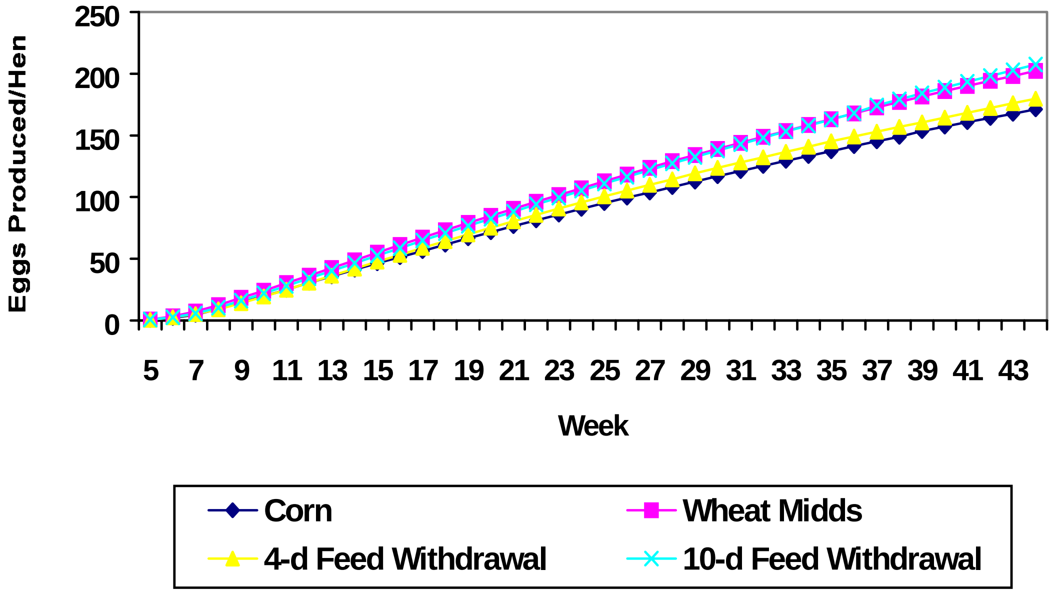

FIGURE 3. Cumulative Hen-Housed Egg Production for Weeks 5-44

After the hens were all fed the layer ration the significant differences between each treatment began to disappear as indicated by similar layer feed consumption for each treatment during Weeks 5 to 44 (Table 4). However, feed efficiency was significantly better for hens deprived of feed compared to those continuously fed.

TABLE 4. Effect of non-feed vs feed removal molting methods on subsequent layer feed consumption and feed efficiency (Wks 5 to 44)

Treatment	Feed consumption	Feed efficiency
	(lbs./100 hens/day)	(lbs./doz. eggs)
Corn	24.0	4.27^{b}
Wheat midds	24.0	4.14^{b}
4-d removal, then corn	23.6	3.80^{a}
10-d removal, then corn	25.0	3.76^{a}

^{a,b}Means within a column with no common superscript differ significantly ($P < .05$).

Table 5 depicts the results for postmolt egg weight, case weights and egg mass. These data show that no significant trends occurred for average egg weights. Postmolt egg mass was greater for hens fed the wheat middlings molt diet compared to those fed the corn molt diet and deprived of feed for 4 days then fed the corn molt diet.

TABLE 5. Effect of non-feed vs feed removal molting methods on subsequent egg weight, case weights, and egg mass (Wks 6 to 44)

Treatment	Egg weight	Case weight	Egg mass
	(g/egg)	(lbs./case)	(g egg/hen/day)
Corn	64.5[a]	51.1	43.6[b]
Wheat midds	63.5[ab]	50.4	47.8[ab]
4-d removal, then corn	64.5[a]	51.1	44.5[ab]
10-d removal, then corn	62.4[b]	49.5	49.2[a]

[a,b]Means within a column with no common superscript differ significantly ($P < .05$).

Table 6 depicts the results for postmolt egg specific gravity. These data show that there were no significant effects of molt treatment on egg specific gravity towards the end of the postmolt production period.

TABLE 6. Effect of non-feed vs feed removal molting methods on subsequent egg specific gravity

	Egg specific gravity (Wks)		
Treatment	6 - 15	41 - 44	6 - 44
	-----------------------(g/cm^3) ----------------------		
Corn	1.080[b]	1.072[a]	1.076[a]
Wheat midds	1.081[a]	1.073[a]	1.077[a]
4-d removal, then corn	1.082[a]	1.074[a]	1.078[a]
10-d removal, then corn	1.082[a]	1.075[a]	1.078[a]

[a,b]Means within a column with no common superscript differ significantly ($P < .05$).

Finally, Table 7 depicts the effect of the molt treatments on postmolt egg income minus feed costs for Weeks 1 to 44. Egg income minus feed costs were compared using the total number of eggs produced and total feed (molt plus layer) consumed for all hens in each treatment. The cost of each molt and the layer diets were calculated using appropriate feedstuff prices (Anonymous, 2000). Egg income was based on a price of $.70 per dozen (Schrader, 2000). As noted in Table 7, the hens which were deprived of feed for 10 days had the highest egg income minus feed costs, with hens fed the wheat middlings molt diet producing the second highest profit.

TABLE 7. Effect of non-feed vs feed removal molting methods on egg income minus feed costs (Weeks 1 to 44)

Treatment	Egg income[1]	Feed cost[2]	Profit	Profit per hen-housed
	($)	($)	($)	($)
Corn	838.72	330.14	508.58	6.05
Wheat midds	991.78	343.52	648.26	7.72
4-d removal, then corn	880.02	337.76	542.26	6.46
10-d removal, then corn	1016.69	351.33	665.36	7.92

[1]Based on $.70 per dozen produced (price estimate Midwest Grade A large white eggs).

Experiment 2

Figure 4 and Table 8 depicts the decrease in daily egg production during the 28-day molt period. Hens that were deprived of feed for 10 days reached 0% production by Day 6. Those hens that were fed the 16% protein molt diet returned to production by Day 23 of the molt period, while those fed the corn diet after the 10-day feed withdrawal period came back into production by Day 24 (1.4%). None of the other six treatments produced total cessation of lay, however, those hens fed the high wheat middlings molt diet reached a low of 2.8% on Day 12 and was at a 6.9% production by Day 28. Similar egg production trends were seen for hens fed the 71% wheat middlings/23% (75/25) corn diet and those fed the corn gluten feed diet. The lowest daily production was .6% for hens fed the corn diet, but overall this treatment did not produce a dramatic reduction in egg production as much as the wheat middlings and corn gluten feed molt diets. Hens fed the corn distillers grain with solubles did not dramatically decrease in egg production compared to the other continuous fed diet treatments. Hens that were deprived of feed for 10 days reached 0% production during Week 2 and 3 and those fed the high wheat middlings diet reached 6.5% by Week 2.

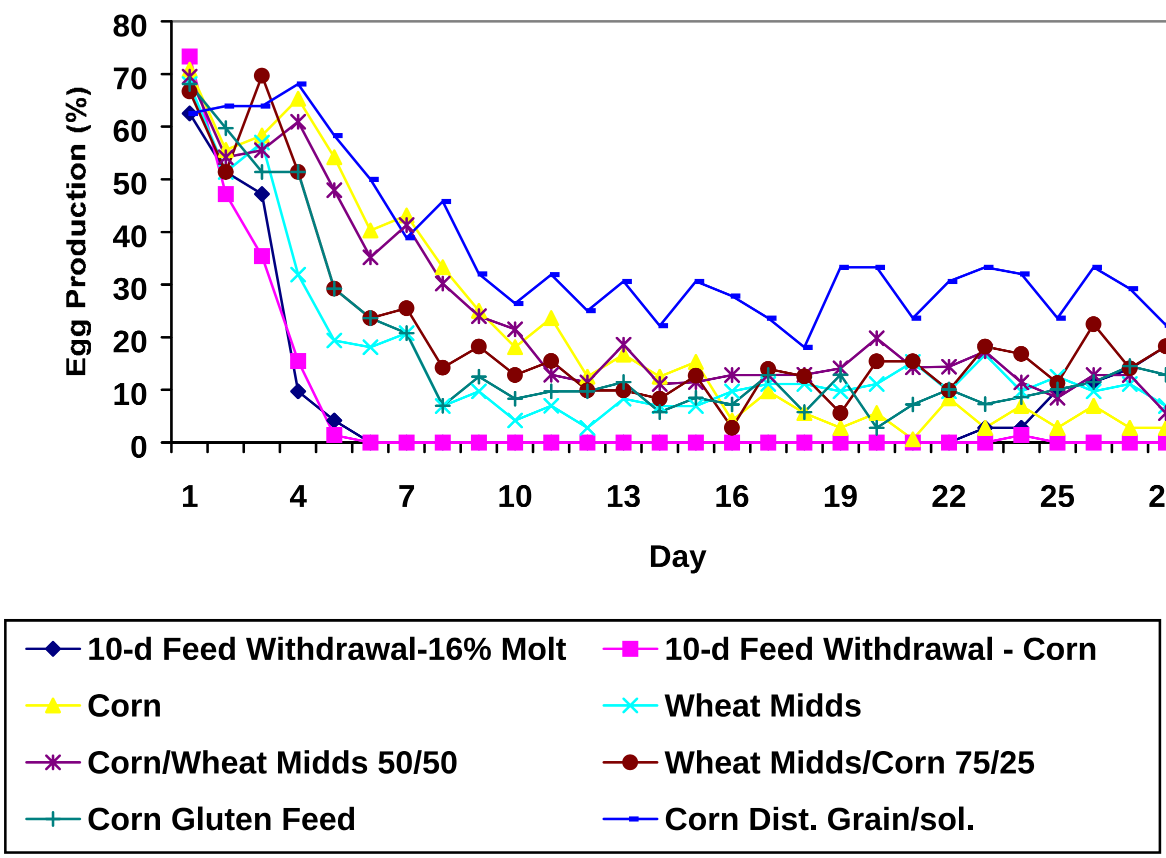

FIGURE 4. Hen-day Egg Production for Days 1-28.

TABLE 8. Effect of non-feed vs feed removal molting methods on hen-day egg production during the molt period

Treatment	Weeks 1	2	3	4
	---(%)---			
Corn	55.4[a]	20.2[b]	6.9[c]	4.8[cd]
Wheat midds	37.1[c]	6.5[cd]	10.7[bc]	10.9[bc]
Wheat midds/corn (47:47)	52.0[a]	18.5[b]	14.0[b]	11.8[bc]
Wheat midds/corn (71:23)	43.9[b]	12.7[bc]	11.2[bc]	15.9[b]
Corn gluten feed	43.5[b]	9.2[c]	8.2[c]	10.7[bc]
Corn dist. grains w/sol.	57.9[a]	30.6[a]	27.2[a]	29.2[a]
10-d removal, then 16% corn-soy	25.0[d]	0.0[d]	0.0[d]	8.5[bc]
10-d removal, then 8% corn	25.3[d]	0.0[d]	0.0[d]	0.2[d]

[a-d]Means within a column with no common superscript differ significantly ($P < .05$).

Body weight loss and mortality during the molt period is depicted in Table 9. Hens that were deprived of feed for 10 days and fed the 16% protein molt diet or 8% protein corn diet lost 24.9 and 27.1% body weight, respectively. Hens that were continuously fed the corn, wheat middlings, corn-wheat middlings combinations, or corn gluten feed lost body weight in the range of 18.4 to 13.8%, with no significant weight loss between treatments at Day 28. However, hens continuously fed the corn distillers grain with solubles lost the least amount of body weight by Day 28 (9.8%). Mortality during the molt period was highest for hens fed the 47:47% wheat middlings/corn diet, however, mortality for this treatment was not different ($P > .05$) for hens fed the 71:23% wheat middlings/corn diet or those fed the corn gluten feed diet.

TABLE 9. Effect of non-feed vs feed removal molting methods on body weight and mortality

Treatment	Initial body wt.	10-day body wt.	28-day body wt.	10-day body wt. loss	28-day body wt. loss	Mortality
	---(lbs./hen)---			---(%)---		
Corn	3.89[a]		3.19[cde]		18.4	0.00
Wheat midds	3.81[a]		3.13[de]		17.9	0.00
Wheat midds/corn (47:47)	3.87[a]		3.27[cd]		15.4	2.80
Wheat midds/corn (71:23)	3.85[a]		3.18[cde]		17.4	1.39
Corn gluten feed	3.83[a]		3.30[bc]		13.8	1.39
Corn dist. grains w/sol.	3.84[a]		3.46[a]		9.8	0.00
10-d removal, then 16% corn-soy	3.86[a]	2.90[a]	3.44[ab]	24.9	10.9	1.39
10-d removal, then 8% corn	3.91[a]	2.85[a]	3.10[e]	27.1	20.8	1.39

[a-e] Means within a column with no common superscript differ significantly ($P < .05$).

Figure 5, Table 10, and Figure 6 shows the return to egg production from Weeks 5 to 44 following the molt period. The hens that were without feed for 10 days, then fed a corn-soybean diet had the highest egg production from Weeks 32 to 44, while those fed the 71:23% wheat middlings/corn diet had slightly lower egg production. Hens that were continuously fed the wheat middlings and corn gluten feed molt diets produced at a faster rate during Weeks 5 to 12 than those fed the corn diet continuously. It took hens that were fed the corn distillers grains with solubles the least number of days to reach 50% production (38; Table 10), whereas, hens that were deprived of feed for 10 days then fed the 8% protein corn diet reached 50% production in the most number of days (56; Table 10). The reason as to why the hens fed the distillers grains reached 50% production the least number of days is because they only reached a low of 30% production during the molt period. The hens fed the 71:23% wheat middlings:corn diet achieved the highest peak egg production. For overall egg production during the postmolt period (Weeks 5 to 44), those hens restricted feed for 10 days, then fed the 16% corn-soybean diet produced at the highest rate (71.5%) and those fed the 47:47% wheat middlings/corn diet produced at the lowest rate (61.5%). For Weeks 1 to 44, the hens fed the 71:23% wheat middlings:corn diet produced the greatest (65.8%). Figure 6 shows the cumulative hen-housed eggs per hen from Weeks 1 to 44. The greatest number of eggs produced per hen occurred for those hens feed restricted for 10 days, then fed the 16% corn-soybean meal diet (199.7), while hens fed the 47:47% wheat middlings:corn diet laid the least number of eggs per hen (174.4). Those fed the wheat middlings and 71:23% wheat middlings corn combination produced nearly as many eggs per hen (193.9) as the conventional molted hens.

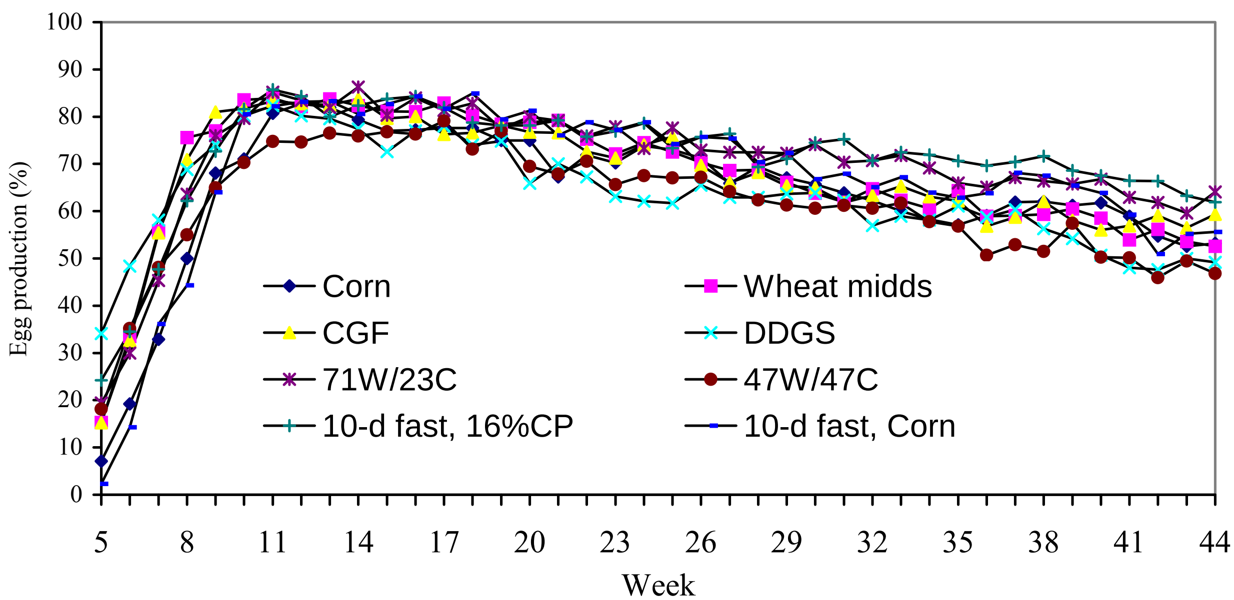

FIGURE 5. Weekly Postmolt Hen-day Egg Production for Weeks 5-44.

TABLE 10. Effect of non-feed vs feed removal molting methods on subsequent egg production

Treatment	Days to 50% production	Peak hen-day production	Egg production Wks 5-44	Wks 1-44
	(days)	(%) (wk)	--------(% H-D)--------	
Corn	51	81.9 (13)	64.2	60.3
Wheat midds	44	83.7 (13)	67.3	62.7
Wheat midds/corn (47:47)	46	79.1 (17)	61.5	58.1
Wheat midds/corn (71:23)	49	86.3 (14)	70.3	65.8
Corn gluten feed	45	83.7 (14)	67.2	62.6
Corn dist. grains w/sol.	38	84.3 (11)	63.7	61.2
10-d removal, then 16% corn-soy	47	85.7 (11)	71.5	65.7
10-d removal, then 8% corn	56	84.9 (18)	67.8	62.0

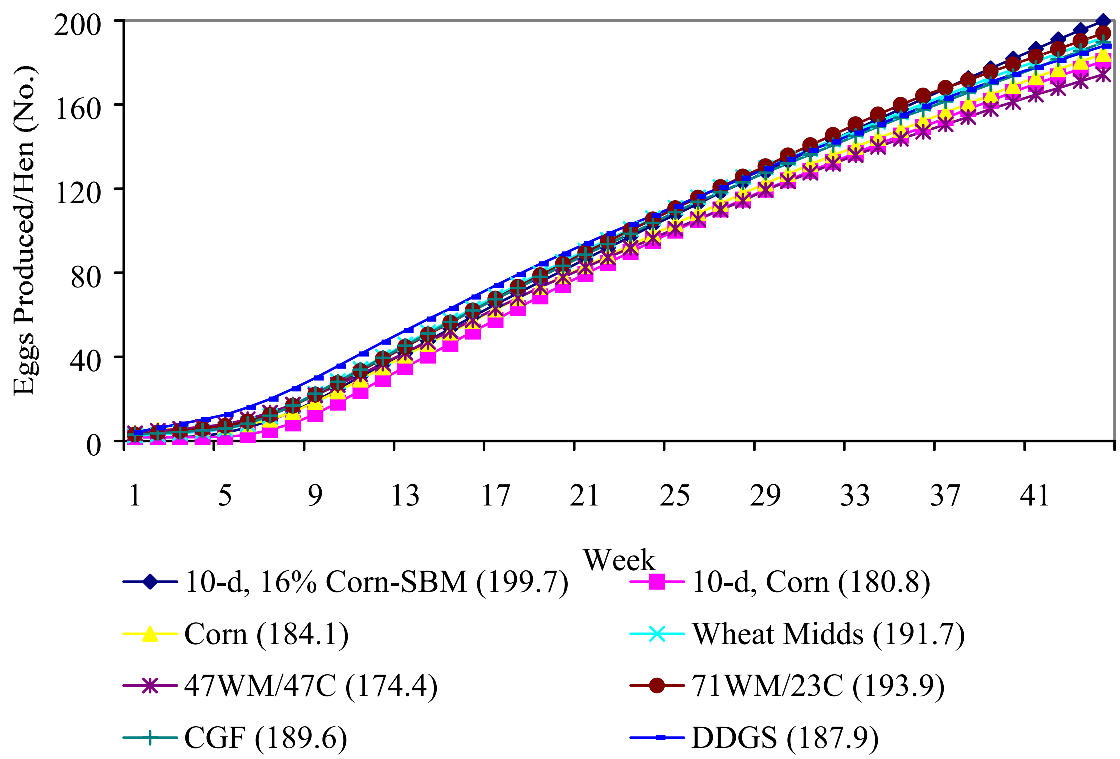

FIGURE 6. Cumulative Hen-Housed Egg Production for Weeks 1-24.

In Table 11, feed consumption during the molt period showed that hens continuously fed the wheat middlings molt diet consumed the least of any continuous fed diet group during the first week, then dramatically increased consumption of this diet the next three weeks. These data agree with that reported for Experiment 1. In addition, the feed consumption trend was nearly the same those hens continuously fed the corn gluten feed.

TABLE 11. Effect of non-feed vs feed removal molting methods on molt feed consumption

Treatment	Weeks 1	2	3	4
	----------(lbs./100 hens/day)----------			
Corn	14.2	13.6	15.3	9.9
Wheat midds	8.2	17.4	20.0	21.4
Wheat midds/corn (47:47)	13.0	17.5	19.1	17.2
Wheat midds/corn (71:23)	9.8	16.9	20.2	17.4
Corn gluten feed	10.1	17.6	21.5	20.4
Corn dist. grains w/sol.	14.9	20.7	21.1	19.1
10-d removal, then 16% corn-soy	-	11.9	20.8	17.0
10-d removal, then 8% corn	-	9.9	19.2	11.8

In Table 12, layer feed consumption for Weeks 6 to 44 ranged from 24.6 to 25.7 lbs. of feed per 100 hens per day for all treatments. The best feed efficiency occurred for hens deprived of feed for 10 days, then fed the 16% protein corn-soybean meal diet (4.2 lbs./doz. eggs), with the poorest feed efficiency noted for hens continuously fed the 47:47% wheat middlings/corn diet (4.7 lbs./doz. eggs).

TABLE 12. Effect of non-feed vs feed removal molting methods on layer feed consumption and feed efficiency

Treatment	Feed consumption Wks 5 to 44	Feed efficiency Wks 6 to 44
	(lbs./100 hens/day)	(lbs./doz. eggs)
Corn	25.1	4.6
Wheat midds	25.2	4.4
Wheat midds/corn (47:47)	24.6	4.7
Wheat midds/corn (71:23)	25.7	4.4
Corn gluten feed	25.1	4.4
Corn dist. grains w/sol.	25.0	4.6
10-d removal, then 16% corn-soy	25.4	4.2
10-d removal, then 8% corn	24.6	4.4

The data for egg weight, case weights, egg mass, and egg specific gravity is depicted in Tables 13 and 14. These data show that minor differences did occur. The heaviest eggs produced were from those hens fed the corn gluten feed diet. Table 14 shows that at the end of the post-molt production period there were no significant differences in egg specific gravity.

TABLE 13. Effect of non-feed vs feed removal molting methods on subsequent egg weight, case weights, and egg mass (Wks 6 to 44).

Treatment	Egg weight	Case weight	Egg mass
	(g/egg)	(lbs./case)	(g egg/hen/day)
Corn	67.3	53.4	44.2
Wheat midds	66.0	52.3	45.2
Wheat midds/corn (47:47)	67.6	53.6	42.4
Wheat midds/corn (71:23)	66.5	52.7	47.6
Corn gluten feed	67.9	53.8	46.4
Corn dist. grains w/sol.	66.7	52.9	43.0
10-d removal, then 16% corn-soy	66.3	52.6	48.2
10-d removal, then 8% corn	66.1	52.4	45.9

TABLE 14. Effect of non-feed vs feed removal molting methods on subsequent egg specific gravity

	Specific gravity (Wks)	
Treatment	6-44	41-44
	-------------------------(g/cm^3)------------------------	
Corn	1.0756	1.0722
Wheat midds	1.0762	1.0723
Wheat midds/corn (47:47)	1.0759	1.0723
Wheat midds/corn (71:23)	1.0761	1.0729
Corn gluten feed	1.0762	1.0730
Corn dist. grains w/sol.	1.0750	1.0725
10-d removal, then 16% corn-soy	1.0770	1.0738
10-d removal, then 8% corn	1.0770	1.0731

Table 15 depicts the economic comparisons between treatments for egg income minus feed costs for Weeks 1 to 44. These results indicate that the most profitable molting program occurred for those hens that had feed withdrawn for 10 days, then fed the 16% corn-soybean meal molt diet. The next best profitable program was the one where hens were continuously fed the 71:23% wheat middlings:corn molt diet.

TABLE 15. Effect of non-feed vs feed removal molting methods on egg income minus feed costs (Wks 1 to 44)

Treatment	Egg income[1]	Feed cost[2]	Profit	Profit per hen-housed
	($)	($)	($)	($)
Corn	662.90	286.98	375.92	5.22
Wheat midds	690.25	277.67	412.58	5.73
Wheat midds/corn (47:47)	624.10	285.81	338.29	4.70
Wheat midds/corn (71:23)	718.95	282.10	436.85	6.07
Corn gluten feed	682.55	264.66	417.89	5.80
Corn dist. grains w/sol.	676.35	275.26	401.09	5.57
10-d removal, then 16% corn-soy	719.00	281.61	437.39	6.08
10-d removal, then 8% corn	650.75	277.07	373.68	5.19

[1]Based on $.60 per dozen produced (Urner Barry Midwest Large; Feedstuffs Aug.-Dec.).
[2]Molt plus layer feed costs.

Tables 16 and 17 depicts the data for ovary and oviduct weight. Both tables reveal that there was a trend for hens continuously fed the wheat middlings or corn gluten feed diets to exhibit ovary and oviduct weight regression. As might be expected, ovary and oviduct weight showed some regression in weight for hens deprived of feed for 10 days, then fed the 16% protein molt diet.

TABLE 16. Effect of non-feed vs feed removal molting methods on ovary weight during the molt period

	Ovary weight (Day)			
Treatment	0	10	21	28
	-------------------(% of body weight) ------------------			
Corn	2.3	2.1	0.6	0.8
Wheat midds	2.3	0.3	0.9	1.6
Corn gluten feed	2.6	1.1	0.2	0.7
Corn dist. grains w/sol.	2.6	1.5	1.1	2.5
10-d removal, then 16% corn-soy	2.9	0.7	0.9	0.2

TABLE 17. Effect of non-feed vs feed removal molting methods on oviduct weight during the molt period

	Oviduct weight (Day)			
Treatment	0	10	21	28
	------------------(% of body weight) -------------------			
Corn	3.1	3.3	1.4	1.6
Wheat midds	2.7	1.2	1.3	2.2
Corn gluten feed	3.6	2.2	0.6	1.1
Corn dist. grains w/sol.	3.0	2.3	1.4	3.5
10-d removal, then 16% corn-soy	3.1	1.7	1.5	0.5

The effect of molting methods on blood heterophic:lymphocyte ratios is depicted in Table 18. These data indicate that there were no clear cut differences noted, however, hens fed the wheat middlings molt diet demonstrated a lower ratio on Day 10 than those hens on the other treatments.

TABLE 18. Effect of non-feed vs feed removal molting methods on blood heterophil:lymphocyte ratio

	Day		
Treatment	0	10	28
Corn	.63	.68	.72
Wheat midds	.89	.55	.54
Corn gluten feed	.64	.64	.68
Corn dist. grains w/sol.	.50	.66	.49
10-d removal, then 16% corn-soy	.60	.63	.48

SUMMARY AND TAKE HOME MESSAGE

In summary, the results of this study indicate that feeding a wheat middlings diet, wheat middlings and corn combination diets, or corn gluten feed molt diet to initiate a molt in commercial layers may be effective alternative feeding programs compared to traditional feed removal methods. The feeding of a wheat middlings molt diet particularly in the first study, and the feeding of this diet in combination with corn (71:23%) provided comparable production performance compared to conventional feed withdrawal method. In addition, the continuous feeding of these molt diets to initiate a molt, did not negatively affect egg shell quality as measured by egg specific gravity in the latter stage of the postmolt egg production period. There were no significant differences in post-molt production performance between hens continuously fed these diets compared to using a conventional method; however, it should be pointed out that numerically better post-molt performance occurred for hens molted the conventional way, then fed a high protein molt diet. Although economic comparisons are subject to many variables, the molting programs utilizing the feeding of a wheat middlings, wheat middlings/corn combination, or corn gluten feed diets may be an economically viable alternative to conventional feed withdrawal molt programs. As previously mentioned for performance, hens molted the conventional manner provided the best economic returns, but the continuous feeding treatments of wheat middlings and wheat middlings-corn combination produced good results. From the results we obtained for the effect of these molting treatments on physiological stress measurement, we can conclude that in our estimation the removal of feed for 10 days did not negatively compromise the hens physiological well-being. In conclusion, if the commercial egg industry is forced by animal rights/welfare pressures to move towards using molting programs which utilize a non-feed removal method, then feeding a wheat middlings, corn-wheat middlings combination, or possibly another type of low energy diet to induce a molt might be considered.

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