ABSTRACT  Induced molting by feed withdrawal has been a common practice in the commercial layer industry and usually involves the removal of feed for a period of up to 14 d. However, this is a practice that is believed to adversely influence the welfare of the hens and there is a need to examine behavioral responses to alternative molt regimens. The behavioral patterns of hens on 90% alfalfa:10% layer ration, 80% alfalfa:20% layer ration, and 70% alfalfa:30% layer ration molt diets were compared with feed withdrawal (FW) hens, and fully fed (FF) hens. The White Leghorn laying hens were approximately 54 wk old and were placed in 3 identical climate-controlled rooms. The hens were individually housed in 2-tier wire battery cages and provided treatment rations and water ad libitum. Nonnutritive pecking, walking, drinking, feeder activity, preening, aggression, and head movement were quantified during two 10-min periods each day for 6 hens from each treatment. Over the 9-d treatment period, hens in the FW, 70% alfalfa:30% layer ration, and 80% alfalfa:20% layer ration groups spent significantly more time walking than hens in the 90% alfalfa:10% layer ration group. The FF and 70% alfalfa:30% layer ration hens spent half as much time preening, whereas the FW hens displayed nearly twice as much nonnutritive pecking when compared with other treatments. Most differences in head movements occurred at the beginning of the molt period, whereas during the last half of molt, alfalfa-fed hens exhibited feeder activity similar to FF hens, and all were significantly higher than that of FW hens. After some initial adjustment by the hens, consumption of alfalfa molt diets appeared to reduce nonnutritive pecking behavior, which is characteristically associated with FW hens.

Key words: behavior, alfalfa-layer ration, laying hen, molt

INTRODUCTION

In the avian species, molting usually involves the periodic shedding and replacement of feathers (Lucas and Stettenheim, 1972). Birds undergo a series of molts during their life span, having at least 4 different plumages from hatching to their first annual cycle. This includes natal down, juvenile, alternate, and basic plummages (Lucas and Stettenheim, 1972). Molting also involves regression of the hens’ reproductive system, resulting in a reproductive quiescence (Berry, 2003). Domestic hens, like most species of wild birds, experience a naturally occurring molt; however, this is usually incomplete, and hens continue to lay eggs at low rates for a prolonged period of time (Swanson and Bell, 1975). This would mean a period of unprofitability because of a reduction in egg production and the end of the useful life of a flock (Berry, 2003). The productive laying life of flocks can be extended from <80 to 110 wk or even 140 wk through the use of induced molting (Bell, 2003). At the end of a laying cycle, egg production and quality decline significantly, but an induced molt usually improves the performance of the hens (Bell, 2003). After the induced molt, egg production and quality are improved significantly compared with the premolt period (Swanson and Bell, 1975; Webster, 2003).

Several different approaches have been developed to induce molt artificially in commercial laying hens. These include feed withdrawal for up to 10 d (Christmas et al., 1985), water withdrawal for 2 d (North and Bell, 1990), and reduction of the photoperiod (Hembree et al., 1980).
The methods that involve feed and water withdrawal have become a matter of concern to animal advocates, and these practices have been banned in Europe (Appleby et al., 2004).

Changes in aggressive behavior during induced molts have been reported, but the results have been contradictory. Aggrey et al. (1990) found that negative interactions among laying hens increased during feed deprivation in open housing systems, but not in battery cages. Hembree et al. (1980) reported that the aggressive behavior of hens in colony cages during feed deprivation did not differ from those of hens not deprived of feed. Webster (1995) found no significant differences in aggression between caged hens on a 4-d fast and hens that were not deprived of feed, whereas Haskell et al. (2000) observed increased aggression in frustrated hens.

In light of the animal welfare controversies associated with feed withdrawal molting, and the additional problem of increased Salmonella Enteritidis infection, alternative means to induce a molt have been sought in the United States (Berry, 2003; Holt, 2003; Ricke, 2003; Park et al., 2004). These alternatives fall into 2 categories, namely, various methods of nutrient restriction that avoid long-term feed withdrawal, and the use of dietary additives (Webster, 2003). Although egg production parameters have been reported extensively in many of these alternative approaches, behavior of the hens has not been examined extensively while they are fed these diets. Some of these alternative molt induction methods have included feeding low-calcium diets (Breeding et al., 1992) and low-sodium, high dietary zinc diets (Berry and Brake, 1985).

Alfalfa and alfalfa-layer ration combinations have been shown to be effective for molt induction, reduction of Salmonella Enteritidis infection, and retention of optimal egg production in the second egg-laying cycle (Donalson et al., 2005; Landers et al., 2005a,b; McReynolds et al., 2005, 2006; Woodward et al., 2005; Dunkley et al., 2007). The objective of this trial was to evaluate the behavioral patterns of hens fed different combinations of alfalfa and layer ration and compare these behavioral patterns with that of feed withdrawal hens in a 9-d induced molt.

**MATERIALS AND METHODS**

A total of 250 Single Comb White Leghorn laying hens, commercial hybrid line Lohman (LSL), approximately 53 wk old, were obtained from a nearby layer unit and used for this trial. Hens were randomly put in 5 treatment groups and were placed in individual cages (800 cm²/bird) in 3 trial rooms for a 2-wk acclimatization period. During this time, they were fed a balanced unmedicated corn- and soybean meal-based mash layer ration that met the NRC requirements for nutrients (NRC, 1994) and were provided water ad libitum. The alfalfa-fed hens were all placed in a single room, whereas hens in the FF treatment and the FW treatment were each placed in a separate room. Identical rooms were used, with lighting, temperature, and ventilation carefully monitored 2 times daily to minimize possible confounding arising from variation between rooms. Rooms were checked for environmental changes to minimize possible confounding effects. A total of 39 hens were placed in each of the 3 treatment groups, and 6 hens from each treatment in clear view of the cameras were observed for behavior patterns.

The treatments consisted of 3 alfalfa rations described by Donalson et al. (2005): A90 consisted of 90% alfalfa meal and 10% layer ration, A80 consisted of 80% alfalfa meal and 20% layer ration, and A70 consisted of 70% alfalfa meal and 30% layer ration. Alfalfa typically contains 17 to 18% CP and 24 to 25% crude fiber and has a low ME (1,200 kcal/kg) when compared with a layer ration with 2,965 kcal/kg (NRC, 1994). Hens in the A90, A80, and A70 treatment groups were fed their respective combination of alfalfa meal and layer ration ad libitum for the 9-d trial. Hens in the fully fed (FF) treatment remained on the pretrial diet, and hens in the feed withdrawal (FW) treatment were not fed during the 9 d of the trial. One week before molt induction, the lighting schedule in each of the 3 rooms was changed from 16L:8D to 8L:16D as described previously (Holt, 1993).

**Behavior Parameters**

Data recordings of predetermined behavioral patterns were carried out by using a 10-camera Digital Video Recorder Multiplexer system (Kalatel DVMRe Triplex eZ Digital Video Multiplexer Recorder, GE Security Kalatel, Corvallis, OR). Two of the cameras were mounted approximately 1.2 m away and 30° above the cages of each treatment in each of the 3 experimental rooms. Two 10-min intervals were analyzed each day from d 0 to 9 of the trial. Recordings were initiated at 1200 h each day and terminated at 1400 h, with one 10-min interval taken at 1230 h and the second 10-min observation at 1330 h. The times were selected to provide the best comparison of the behavior of the control (FF) hens and the other treatments because most of the control hens would have finished their prelaying behavior and they would already have laid by 1200 h (Mills and Wood-Gush, 1985; Webster and Hurnik, 1990). Recordings were ended by 1400 h to avoid recording any increased feed intake by the control (FF) hens in anticipation of darkness (Savory, 1980).

Six hens in individual cages were subjects for the behavioral analysis in each treatment. Seven different behaviors, which were defined in an ethogram (Table 1) adapted from Webster (2000), were used to assess the birds’ welfare during the trial. Aggressive behavior was reported as a one-zero sampling, in which the observer scored whether a behavior occurred (one) or not (zero) (Lehner, 1998). All other data were in the form of counts at 1-min intervals, which were then summarized as the daily mean percentage of observations in which the subject was performing a particular behavior.

**Statistical Analysis**

All data were subjected to arcsine square root transformation, after which the average of each activity of the
Table 1. Ethogram of laying hen behaviors examined

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggression</td>
<td>Pecking directed at other hens in neighboring cages</td>
</tr>
<tr>
<td>Drinking</td>
<td>Apparent ingestion of water by pecking from the nipple waterers</td>
</tr>
<tr>
<td>Feeder</td>
<td>Any pecking behavior directed toward the feeding trough when the focal bird was close enough to eat or when her head was in the trough</td>
</tr>
<tr>
<td>Head movement</td>
<td>Rapid individual head movement of an alert bird</td>
</tr>
<tr>
<td>Nonnutritive pecking</td>
<td>Pecking at anything other than the feed; this includes the cage floor, sides, or their own feet</td>
</tr>
<tr>
<td>Preening</td>
<td>Manipulation of plumage with the beak</td>
</tr>
<tr>
<td>Walking</td>
<td>Locomotion involving at least one step</td>
</tr>
</tbody>
</table>

1Adapted with some modifications from Webster (2000).

hens in each treatment over the 9-d period was analyzed by using a repeated measures design. The GLM procedure of SAS (SAS version 8.3, SAS Institute Inc., Cary, NC) was used, with treatment, time, treatment × time interaction, and individual hens nested within treatment as the factors. Chicken nested within treatment was the error term used to test for treatment effects. When significant (P ≤ 0.05) arcsine treatment × time interactions were found, means were compared by least squares means, and the untransformed percentage means are reported in the respective figures.

RESULTS AND DISCUSSIONS

Egg Production

Egg production data were collected and the A80 hens stopped laying on d 5 of the trial, whereas the FW and A90 hens ceased production on d 6 (Figure 1). The A70 hens did not completely cease egg production through d 9 of the trial. Donalson et al. (2005) reported that A70 hens required an average of 6 d to cease egg production, whereas A90-fed hens and the FW hens stopped laying between 4 and 5 d after molt induction (they did not examine A80 hens). This response, however, was not significant (P > 0.05). These results could be due to an incomplete molt caused by the higher amount (30%) of high-calorie layer ration in the A70 feed.

Aggression

Aggressive pecking at neighboring hens was minimal in this trial, with few differences between the FW hens and the non-FW hens. One incidence was observed between hens in groups A90 and A70 on d 1 of the trial. Aggressive behavior was also observed between hens in the FF and FW groups on d 3 of the trial (data not shown). The low incidence of aggression observed in our trial could be because the hens were housed in individual cages, thereby minimizing the bird-to-bird interaction usually seen in multihen or colony cages. Webster (2000) and Anderson et al. (2004) evaluated the behavior of caged laying hens in groups of 3 or 6 hens per cage. When they induced molt by feed withdrawal, they observed aggression during the first to third day after molt induction; this declined, however, after d 3 and was not different from the nonmolted hens. This reduction in aggressiveness was not observed by McCowan et al. (2006) when they induced molt either by feed deprivation or by incorporating a low-calorie-density layer diet. They did observe an increase in aggression throughout the 10-d induced molt.

Walking Activity

Overall treatment effects (P ≤ 0.05) were observed for the 9-d trial, but the treatment × day effect was not signifi-
cant \((P > 0.358)\). During the trial, the FW, A80, and A70 hens spent significantly more time walking than the A90 hens (Table 2). However, only the FW hens walked more than the FF hens, and only the FF hens walked more than the A90 hens. The walking behavior observed in this trial was not consistent with the observations by McCowan et al. (2006), who reported no significant differences among the treatments throughout the molt period. Hens that were feed deprived would be expected to reduce their activities in an effort to conserve energy (Murphy, 1996). Webster (2000) observed that hens undergoing feed withdrawal spent a high percentage (40%) of their time resting during an induced molt.

**Preening Activity**

During the 9-d trial, significant differences \((P \leq 0.05)\) were observed among the treatment groups, but there was no treatment \(\times\) day effect \((P > 0.19)\). During this period, the FF and A70 hens spent less than half the time preening compared with hens in the other treatment groups (Table 2). This increased preening could have been a result of follicular irritation caused by feather push-out. Through subjective observations, we noted an increase in feathers under the cages of the FW hens on d 8 and under the cages of the A80 and A90 hens on d 9 (data not shown). Shedding was not observed in the A70 hens until d 12 (2 d after the treatment diet ended and the hens were returned to their normal diet). Preening may be performed as a displacement action in situations of conflict or frustration (Duncan and Wood-Gush, 1972). However, Webster (2000) reported that the amount of time that was spent preening followed a quadratic trend that peaked toward the end of an induced molt. Webster postulated that rather than attributing the increased preening to frustration, it could be attributed to a response to feather push-out.

**Nonnutritive Pecking**

Over the 9-d period, FW hens spent nearly twice \((P \leq 0.05)\) as much time engaged in nonnutritive pecking compared with the treatment groups receiving feed (Table 2), but there was no treatment \(\times\) day effect \((P > 0.09)\). The A70 and A90 groups exhibited the greatest activity, whereas the activity of the A80 group was similar to that of the FF hens. Nonnutritive pecking is thought to be redirected foraging behavior that is seen in birds in the wild (Petherick and Rutter 1990), and it has been reported that even when hens are provided with adequate food, they are still motivated to forage (Duncan and Hughes, 1972). Hens will act in a predictable manner in response to feed deprivation (Petherick and Rutter, 1990) by working harder for food the longer they have been without it. Other reports in studies in which hens were deprived noted that feed-restricted chickens usually exhibited more than a 3-fold increase in nonnutritive pecking (Savory and Fisher, 1992; Savory et al., 1992; Webster, 2000; McCowan et al., 2006).

**Head Movement**

A significant \((P \leq 0.05)\) treatment \(\times\) day effect was observed for head movements (Figure 2). On d 1 of the trial, the A90 hens spent significantly less feeder time than hens in all other treatment groups, whereas the A80 hens exhibited the most head movements and the A90 hens the fewest head movements. On d 3 and 4, more head movements were observed in A90 hens than in FW hens, whereas on d 9, FF hens exhibited more head movements than A80 hens. However, most of the differentiation in head movements occurred at the beginning of the trial and no significant differences in head movement were observed on d 5, 6, 7, and 8 (Figure 2). Similar results were found by Webster (2000), who also noted that the

### Table 2. Mean behavior of hens for the 9-d trial

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Walking</th>
<th>Preening</th>
<th>Nonnutritive pecking</th>
</tr>
</thead>
<tbody>
<tr>
<td>A70</td>
<td>18.45 ± 5.71&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.83 ± 2.88&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.65 ± 6.59&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arcsine transformation</td>
<td>2.85 ± 0.52&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.31 ± 0.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.32 ± 0.52&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>A80</td>
<td>17.28 ± 8.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.34 ± 4.83&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.40 ± 5.09&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arcsine transformation</td>
<td>2.57 ± 0.61&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.98 ± 0.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.62 ± 0.43&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>A90</td>
<td>5.87 ± 1.73&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.20 ± 4.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.96 ± 6.69&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arcsine transformation</td>
<td>1.74 ± 0.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.18 ± 0.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.61 ± 0.51&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>FF</td>
<td>12.70 ± 2.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.16 ± 2.31&lt;sup&gt;b&lt;/sup&gt;</td>
<td>18.64 ± 6.36&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arcsine transformation</td>
<td>2.54 ± 0.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.46 ± 0.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.89 ± 0.52&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>FW</td>
<td>18.64 ± 5.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.54 ± 5.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.91 ± 5.41&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Arcsine transformation</td>
<td>2.88 ± 0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.13 ± 0.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.67 ± 0.51&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a–d</sup>Means within columns that represents percentage of observation for the 9-d period or arcsine transformation for the 9-d period with the same superscript are not different \((P \geq 0.05)\).

<sup>1</sup>A70 = 70% alfalfa meal + 30% layer ration; A80 = 80% alfalfa meal + 20% layer ration; A90 = 90% alfalfa meal + 10% layer ration; FF = fully fed hens; FW = feed withdrawal hens.
Figure 2. Percentage of observations of head movement behavior of laying hens during molting. Results represent the daily mean percentage of observations spent in the activity from the 5 groups of hens in the experiment; n = 6 hens per treatment group. Treatments within the same day with different letters are different at \( P \leq 0.05 \). A70 = 70% alfalfa meal + 30% layer ration; A80 = 80% alfalfa meal + 20% layer ration; A90 = 90% alfalfa meal + 10% layer ration; FF = fully fed hens; FW = feed withdrawal hens.

Figure 3. Percentage of observations of drinking behavior of laying hens during molting. Results represent the daily mean percentage of observations spent in the activity from the 5 groups of hens in the experiment; n = 6 hens per treatment group. Treatments within the same day with different letters are different at \( P \leq 0.05 \). A70 = 70% alfalfa meal + 30% layer ration; A80 = 80% alfalfa meal + 20% layer ration; A90 = 90% alfalfa meal + 10% layer ration; FF = fully fed hens; FW = feed withdrawal hens.

The highest frequency of head movement occurred during the first 3 d of feed withdrawal, with no differences between the FW and nonmolted hens during the last days of feed withdrawal. In the current study, hens fed the alfalfa-layer ration were no less attentive during the induced molt; they displayed overall means that were similar to those of the FF hens (data not shown). When McCowan et al. (2006) evaluated the behavior of fast-molted (feed-deprived) laying hens, low-calorie-molted laying hens, and nonmolted laying hens, they reported no significant differences among treatments in head movements.

Drinking Activity

A treatment \( \times \) day effect (\( P \leq 0.05 \)) was observed in drinking activity (Figure 3). On d 1 of the trial, FF hens spent more time drinking than the A80, A70, and FW hens, whereas on d 5 and 6, FF hens spent more time drinking than hens in all other treatment groups. On d 8, FF hens spent significantly more time drinking than the A90, A70, and FW hens. Woodward et al. (2005) observed that FF hens drank nearly twice as much as 100% alfalfa meal-fed and FW hens. Webster (2000) found that drinking behavior declined in feed-deprived hens after the first few days of feed withdrawal. On the basis of our results and the results of other studies (Donalson et al., 2005; Woodward et al., 2005), it appears that because FW hens were not eating, they tended to drink less, whereas FF hens, when provided a dry ration, typically drank more water. The current study results are also consistent with those of Donalson et al. (2005), who reported that A90 hens consumed nearly 3-fold less water than FF hens, whereas A70 hens consumed almost 2-fold less.

Feeder Activity

Significant (\( P \leq 0.05 \)) treatment \( \times \) day effects were observed in percentage of feeder activity (Figure 4). On d 1 of the trial, the A70 and A90 hens spent significantly more time at the feeder than hens in all the other treatments except FF hens. On d 3, the FF hens were at the feeder more often than the A80 and FW hens, whereas on d 4, the A80 hens were at the feeder only more than
the FW hens. On d 6, 7, 8, and 9, the FW hens spent significantly less time at the feeder than hens in all the other treatments except for FF hens on d 8. Generally, hens provided with feed spent more time at the feeder than did the FW hens. Because we could not tell whether a bird was eating, we scored each time the bird visited the feeding troughs, and because of this, the FW hens were occasionally given a score for feeding. The initial reduction in feeder visits by alfalfa-fed hens followed by increased visits could represent a behavioral adjustment period for these hens to the change of diet. It has been noted previously that hens fed 100% alfalfa meal diets eat significantly less than hens fed layer ration (Woodward et al., 2005; Donalson et al., 2005). The reduced intake of the alfalfa diet early in the trial could also be due to the unpalatability of alfalfa because of the presence of saponins (Sen et al., 1998) or bulk fill satiety caused by the slow passage of the alfalfa through the gastrointestinal tract of the chicken (Sibbald, 1979, 1980). When Donalson et al. (2005) compared different ratios of alfalfa diets, they observed that the A70 hens ate almost twice as much as the A90 hens. We also observed what appeared to be a relationship between feeder activity and nonnutritive pecking because as nonnutritive pecking declined in frequency, feeder activity increased, indicating that the reduction in frequency of feeding was not entirely dependent on the specific dietary treatment. Webster (1995, 2000) reported a similar relationship when hens were molted by feed deprivation, stating that hens undergoing feed withdrawal spent progressively less time (8-fold) visiting the feeder as the molt period progressed.

In conclusion, the use of different combinations of alfalfa diets to induce a molt was explored previously (Donalson et al., 2005) and the A70 was the least favorable because of the incomplete regression of the reproductive tract. This is consistent with the results in the current study, because the A70 hens spent less time preening, began shedding feathers at a later date than birds fed the other 2 alfalfa diets, and did not completely stop laying by d 9. However, the A90 and A80 hens stopped laying at a time that was comparable to the FW hens, making these the optimal dietary regimens for molt induction.

Little behavioral work has been reported on the effects of alternative molt diets on laying hens. The general behavioral responses reported in the current study relate specifically to the commercial hybrid line Lohman (LSL) and indicate that using alfalfa-layer ration-based diets to induce molt in laying hens has potential to address some of the concerns regarding molt. The hens fed alfalfa-layer ration diets exhibited consistent head movement and walking activities throughout the trial. At the beginning of the trial, the hens fed alfalfa diets spent similar amounts of time performing nonnutritive pecking as the FW hens; however, this declined toward the end of the trial. In contrast, nonnutritive pecking behavior in the FW hens increased toward the end of the trial. The reduction in nonnutritive pecking behavior coincided with an increase in feeder-related activity, indicating that the hens required some time to become accustomed to the alfalfa diets.

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REFERENCES


