

Chemical and Non-chemical Molting Methods as Alternatives to Continuous Feed Withdrawal in Laying Hens

S. Karimi¹, F. Khajali^{1*}, and H. R. Rahmani²

ABSTRACT

An experiment was conducted to evaluate the effectiveness of chemical and non-chemical molting methods as compared to conventional feed removal methods with respect to the physiological response and postmolt performance in Hy-line W36 laying hens. One hundred and eight 78-week-old hens were distributed among 27 groups of four birds and placed in cages so that the mean body weight of each cage was very similar. Three adjacent cages were considered as a replicate and 3 such replicates were assigned to each treatment. There were three treatments (molting procedures). Treatment 1 was continuous feed removal (CFR) and considered as the control. Hens on treatment 2 (T2) were fed finely ground delinted whole cottonseed as the sole feed ingredient and dietary vitamin and macro and microelement levels were maintained according to Hy-line W36 guideline specifications. Birds on treatment 3 (T3) received a layer diet containing 5,000 ppm Zn and fed at the rate of 50 g b⁻¹ d⁻¹. The results indicated that hens subjected to CFR, whole cotton seed and zinc supplemented diet went out of production on Day 6, Day 7 and Day 14, respectively. Continuous fasting and feeding whole cottonseed as molting programs resulted in significantly ($P < 0.05$) lower body weight and serum T₃ concentrations but higher heterophil to lymphocyte (H:L) ratio and hematocrit, compared to the zinc method when measured on Day 7. Birds that received molt diet supplemented with zinc produced heavier eggs postmolt ($P < 0.05$) in comparison to other treatments but the egg production, egg mass and egg quality criteria were not different among the treatments.

Keywords: Cotton seed, Fasting, Laying hens, Molting, Zinc.

INTRODUCTION

Molting in avian species is defined as the periodic shedding and replacement of feathers which is accompanied by involution of the reproductive organs (Berry, 2003). Natural molting in laying hens generally takes four months (North and Bell, 1990), which raises economic concerns as the hens continue to be fed during non-productive times (McDaniel and Aske, 2000). The molting process can be sped up by using a management practice called induced

molting. Induced molting uniformly rests all hens and returns them to a more consistently high rate of lay for an extended period (McDaniel and Aske, 2000). A conventional induced molting program usually involves a period of fasting for 10 to 15 days or up to the point a 30% body weight reduction is achieved (Ruszler, 1998). Hens subjected to continuous fasting experience stress and are highly susceptible to infection by salmonella (Holt, 2003). The egg industry, therefore, should seek for alternative molting programs to replace continuous feed removal.

¹ Department of Animal Science, College of Agriculture, Shahrekord University, Shahrekord, Islamic Republic of Iran.

² Department of Animal Science, College of Agriculture, Isfahan University of Technology, Isfahan, Islamic Republic of Iran.

* Corresponding author, e-mail: khajali@agr.sku.ac.ir



Several non-feed removal procedures were used to induce molting in hens. Koelkebeck *et al.* (2006) have studied the effectiveness of a corn or a wheat diet fed at free access for induction of molt and indicated that layer performance was inferior than with the feed removal procedure. Feeding a high zinc diet was successfully used by Park *et al.* (2004) while use of high fiber diets provided by alfalfa (Landers *et al.*, 2005) or whole cottonseed (Davis *et al.*, 2002) was reported to be as effective as a complete feed removal program. However, physiological responses were not well appreciated in detail under the aforementioned circumstances. The present study looks at the physiological responses as well as postmolt performance of a chemical and a non-chemical molting program compared to continuous feed removal.

MATERIALS AND METHODS

One hundred and eight 78-week old Hy-line W36 laying hens were kept in a house equipped with cages (40×45 cm) and exposed to a 16 hour daily photoperiod. Prior to beginning the experiment, all hens were weighed and distributed among 27 cages so that four hens were allotted to each cage with an equal mean body weight in each cage. Three adjacent cages were considered as a replicate and 3 such replicates were assigned to each treatment. There were three treatments (molting procedures). Treatment 1 was continuous feed removal (CFR) and considered as the control. Hens on treatment 2 (T2) were fed finely ground delinted whole cottonseed as the sole feed ingredient and dietary vitamin and macro and microelement levels were maintained according to Hy-line W36 guideline specifications. Birds on treatment 3 (T3) received a layer diet containing 5,000 ppm Zn (in form of ZnO) and fed at the rate of 50 g b⁻¹ d⁻¹.

The experiment lasted for 16 weeks and consisted of a four-week period of molt and a 12 week postmolt laying period. On Day 1 of molt (the initiation of feed withdrawal),

the daily photoperiod was decreased to 8 hours. On Days 24 and 30, the photoperiod was increased to 10 and 12 hours, respectively, and then increased 30 minutes per week until a photoperiod of 16 hours was reached at peak production. As soon as a 30% weight loss occurred, hens were fed on the Molt 1 diet freely according to the Hy-line W36 commercial management guide manual (2005) during postmolt period.

Records of body weight before the induction of molt (Day 1), Day 14 (mid-molt) and Day 28 (end of the molt period) were kept to make a comparison among the molting methods. In addition, records of body weight were kept and checked more frequently to assure whether approximately 30% weight loss had been attained.

Blood samples were taken from the brachial vein of one hen per replicate (9 hens treatment⁻¹) on Day 1 (before molt), Day 14 (mid-molt) and Day 28 (end of molt). Blood samples were used for the determination of hematocrit and differential leukocyte counts (Khajali *et al.*, 2006). Serum was obtained from blood centrifuged at 1,400 g for 15 minutes and sera samples were used to measure T₃ and T₄ hormone concentrations by radioimmunoassay using a commercial kit (REF KT2CT, Barcelona, Spain). Records of egg production were kept daily for 12 weeks post molt and records of egg weight were kept monthly during the aforementioned period.

Data were subjected to a nested design and analyzed by the GLM procedure of SAS software (1997). Duncan's multiple range test was used to compare treatment means.

RESULTS

The reduction in hen-day egg production during a 28-day molt period is shown in Figure 1. The figure indicates that hens on continuous feed removal, whole cottonseed and zinc supplemented diet went out of production by Day 6, Day 7 and Day 14, respectively.

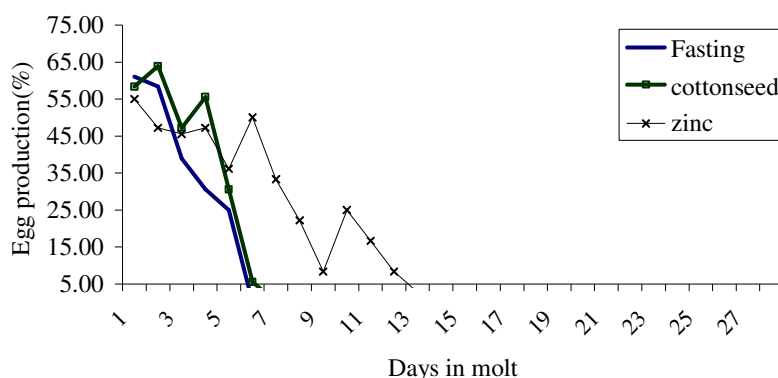


Figure 1. Regression in egg production during molting period among molting programs.

Birds on a continuous fasting regime and those fed whole cottonseed reached 30% weight loss on Day 12 and were then fed the same postmolt diets according to Hy-line management guidelines up to peak production. Birds on a zinc diet never reached 30% weight loss and were kept on zinc diet up to the end of the molt period (Day 28), followed Hy-line management guidelines up to peak production.

Table 1 depicts body weight changes in hens measured at different times during the molt period under different molting programs. Hens on fasting and whole cottonseed diets lost 23.7 and 19.4% of their initial body weight by Day 7, and around 30% of their body weight by Day 12, which was significantly greater than those hens fed a zinc-supplemented diet.

Birds fed a zinc-supplemented diet had a

significantly ($P < 0.05$) higher plasma T_3 concentration but a significantly lower H:L ratio and hematocrit than those on fasting and whole cotton seed when compared on Day 7. Nevertheless, the differences with respect to these variables were not significant on Days 14 and 28 (Tables 2 and 3).

Table 4 depicts results pertaining to hen-day egg production, egg weight, egg mass and quality criteria during the postmolt period. Hens on a zinc-supplemented diet had a significantly ($P < 0.05$) higher egg weight in comparison with other groups. However, egg production, egg mass and quality measures during the postmolt period did not differ significantly among the treatments.

Table 1. Body weight changes in hens subjected to different molting programs at different times during the molt period.

Molting procedure	Body weight (g)			
	Day 0	Day 7	Day 14	Day 28
Continuous fasting	1616	1232(23.7) ^b	1177(27.1) ^b	1365(15.5)
Cottonseed	1625	1309(19.4) ^b	1226(24.6) ^b	1326(18.4)
Zinc	1650	1535(6.9) ^a	1460(11.5) ^a	1366(17.2)
SEM	25.24	21.07	21.28	32.13

Means within each column with uncommon superscript have significant difference ($P < 0.05$). Data in parentheses show body weight loss as a percent of initial body weight.

**Table 2.** Thyroid hormone concentrations of hens subjected to different molting programs at different times during the molt period.

Molting procedure	T3 (ng dl ⁻¹)				T4 (μg dl ⁻¹)			
	Day 0	Day 7	Day 14	Day 28	Day 0	Day 7	Day 14	Day 28
Continuous fasting	233.8	176.8 ^b	242.6	269.4	1.00	1.85	2.14	1.53
Cottonseed	267.4	204.7 ^a _b	230.8	319.8	1.06	1.61	1.60	1.70
Zinc	257.3	238.9 ^a	212.7	303.5	1.08	1.51	2.24	1.14
SEM	16.84	25.75	21.12	28.99	0.08	0.31	0.31	0.26

Means within each column with uncommon superscript have significant difference (P< 0.05).

DISCUSSION

Birds subjected to continuous fasting ceased egg production much earlier than those on chemical and non-chemical molting programs. This observation was definitely expected as hens on the control received no nutrient to maintain egg production. Nevertheless, hens that received whole cottonseed followed a very similar regression trend in egg production. This implies that whole cottonseed acts strongly as a feed-reducing factor since hens showed very little interest in such a diet and tried to separate other feed ingredients from the cottonseed. However, the cottonseed was finely ground and mixed in their feed to stop the birds from choice feeding. There is also the possibility that gossypol in the cottonseed tended to stop egg production.

Hens on a fasting regime and whole cottonseed diet lost their body weight significantly (P< 0.05) more than those hens fed a zinc-supplemented diet. The

remarkable weight loss of hens on a whole cottonseed diet was due to the fibrous and bulky texture of this feedstuff as well as its poor palatability which reduced the voluntary feed intake of the birds (Nagalakshmi *et al.*, 2007). The major weight loss may be due to regressions in ovary, oviduct and liver as indicated by researchers (Khajali *et al.*, 2007). On the other hand, birds in the control group gained a higher weight than during refeeding so that they had an even higher body weight on Day 28 compared to the other groups.

Cessation of feed consumption by Day 7 during molt led to decreased serum T₃ concentration in the fasting and whole cottonseed groups compared to the zinc-supplemented group (Table 2); this finding is consistent with previous reports (Reyns *et al.*, 2002; Decuyper *et al.*, 2005). The decrease in circulatory T₃ level in feed deprived hens is likely to be the result of a shift in the balance between deiodination of T₄ by hepatic deiodinase enzyme Type I (D1) and T₃ degradation by hepatic

Table 3. Hematocrit and heterophil to lymphocyte ratio in hens subjected to different molting programs at different times during the molt period.

Molting procedure	Hematocrit				H:L (%)			
	Day 0	Day 7	Day 14	Day 28	Day 0	Day 7	Day 14	Day 28
Continuous fasting	38.4	41.6 ^a	39.4	38.8	0.33	0.87a	0.80a	0.48
Cottonseed	37.8	38.7 ^{ab}	38.2	40.7	0.41	0.77a	0.58b	0.63
Zinc	38.2	35.3 ^b	39.8	40.4	0.36	0.57b	0.50b	0.55
SEM	1.82	0.88	1.68	0.60	0.03	0.11	0.08	0.06

Means within each column with uncommon superscript have significant difference (P< 0.05).

Table 4. Postmolt performance of laying hens subjected to different molting programs.

Molting procedure	Postpeak hen-day egg production ^a (%)	Egg weight (g)	Mean egg mass (g)	Eggshell thickness (mm)	Eggshell strength (kg cm ⁻²)	Albumin height (mm)
Continuous fasting	78.1	63.9 ^b	3042	0.400	3.70	4.39
Cottonseed	71.1	65.0 ^{ab}	2769.0	0.396	3.40	5.25
Zinc	69.0	67.1 ^a	2778.0	0.404	3.86	4.86
SEM	3.48	0.69	290.0	0.013	0.19	0.25

Means within each column with uncommon superscript have significant difference ($P < 0.05$).

^a Data included the period of 5% production rate to peak.

deiodinase enzyme Type III (D3) (Decuyper *et al.*, 2005). Decuyper *et al.* (2005) reported increased hepatic deiodinase III mRNA levels on the first day of starvation which dropped after refeeding. As indicated in Table 2, refeeding during molt restored changes in serum thyroid hormone concentrations. This implies that serum thyroid hormone changes are mediated through feed intake changes during molting.

Birds fed a zinc-supplemented diet had significantly ($P < 0.05$) lower H:L ratio and hematocrit than those on fasting and whole cottonseed regimes when compared on Day 7. This finding implies that starvation during molting resulted in an elevated hematocrit and H:L ratio. There are reports suggesting that starvation during molting increases packed cell volume (Keshavarz and Quimby, 2002). Molting causes a remarkable regression in ovary and oviduct weight (Khajali *et al.*, 2007) which is associated with the loss of estrogenic activity. According to Keshavarz and Quimby (2002), the loss of estrogenic activity could result in increased erythropoiesis and accounts for enhanced hematocrit.

The heterophil to lymphocyte ratio is commonly used as an indicator of stress (Vleck, 2001); under stress conditions the ratio is tended to increase (Davis *et al.*, 2000). Davis *et al.* (2000) showed that the H:L ratio was significantly higher during a forced molt compared to other times of year. As depicted in Table 3, birds that

experienced fasting showed the highest rate of H:L (compare the treatments on Day 7). This finding shows that fasting during molting places a heavy stress on the birds. This is consistent with our previous report (Khajali *et al.*, 2008).

Hens fed a zinc-supplemented diet had a significantly ($P < 0.05$) higher egg weight. This finding can be explained by the critical role of this element for carbonic anhydrase enzyme in the shell gland. This enzyme plays a critical role in eggshell formation. As Table 4 indicates, shell thickness and its strength against breaking are numerically higher in the zinc-supplemented group than in other groups; however, the differences were not significant. There is also the possibility that increased egg weight in birds on a Zn-supplemented diet is, in part, due to the higher body weight of the hens since they had the lowest weight loss during molting. Nevertheless, postmolt egg mass were not significant among the treatments.

Research conducted in Iran implied that continuous feed removal was the best method of induced molting (Golian *et al.*, 1991; Barzegari Nafari, 1998) when taking into account postmolt egg production. However considering physiological responses, especially the H:L ratio (measure of stress), it can be concluded that the chemical and non-chemical methods used here will be effective alternatives to continuous fasting.



CONCLUSIONS

The findings of the present study indicate that both chemical and non-chemical molting methods can be satisfactory when used as alternatives to the conventional long fasting method and additional benefits will be gained as a result of alleviating the stress of fasting.

REFERENCES

1. Barzegari Nafari, S. 1998. Comparison of Different Induced-molting Methods for Laying Hens. MSc. Dissertation, Isfahan University of Technology.
2. Berry, W. D. 2003. The Physiology of Induced Molting. *Poult. Sci.*, **82**: 971- 980
3. Davis, G. S., Anderson, K. E. and Carroll, A. S. 2000. The Effect of Long-term Caging and Molt of Single White Leghorn Hens on Heterophil to Lymphocyte Ratios, Corticosterone, and Thyroid Hormones. *Poult. Sci.*, **79**: 514- 518.
4. Davis, A. J., Lordelo, M. M. and Dale, N. 2002. Use of Cottonseed Meats in Molting Programs. *J. Appl. Poult. Res.*, **11**: 175-178.
5. Decuyper, E., Van As, P., Van der Geyten, S. and Darras, V. M. 2005. Thyroid Hormone Availability and Activity in Avian Species: A Review. *Domestic Anim. Endocrinology*, **29**: 63- 77.
6. Golian, A., Tahmasebi, A., and Kermanshahi, H. 1991. Comparison of Three Induced-molting Methods on Laying Hen Performance during the Second Production Cycle. *J. Agric. Sci. Technol.*, **5**: 155-167.
7. Holt, P. S. 2003. Molting and *Salmonella enterica* serovar *enteritidis* Infection: The Problem and Some Solutions. *Poult. Sci.*, **82**: 1008-1010.
8. Keshavarz, K. and Quimby, F. W. 2002. An Investigation of Different Molting Techniques with an Emphasis on Animal Welfare. *J. Appl. Poult. Res.*, **11**: 54- 67.
9. Khajali, F., Asadi Khoshouie, E. and Zamani Moghaddam, A. K. 2006. Effect of Vitamin and Trace Mineral Withdrawal from Finisher Diets on Growth Performance and Immunocompetence of Broiler Chickens. *Br. Poult. Sci.*, **47**: 159- 162.
10. Khajali, F., Asadi Khoshouie, E. and Rafiei, F. 2007. Application of Short Fasting Methods to Induce Molting in Commercial Laying Nens. Proc. of 16th European Poultry Nutrition Conference, Strasbourg, France. 55-57
11. Khajali, F., S. Karimi, and M. R. Akhari, 2008. Physiological Response and Postmolt Performance of Laying Hens Molted by Non-feed Removal Methods. *Am. J. Anim. Vet. Sci.* **3**: 13- 17.
12. Koelkebeck, K. W., Parsons, P. W., Biggs, P. and Utterback, P. 2006. Nonwithdrawal Molting Programs. *J. Appl. Poult. Res.*, **15**: 483-491.
13. Landers, K. L., Woodward, C. L., Li, X., Kubena, F., Nisbet, D. J. and Ricke, S. C. 2005 b. Alfalfa as a Single Source for Molt Induction in Laying Hens. *Bioresource Technol.*, **96**: 556- 570.
14. McDaniel, B. A. and Aske, D. R. 2000. Egg Prices, Feed Costs, and the Decision to Molt. *Poult. Sci.*, **79**: 1243- 1245.
15. Nagalakshmi, D., Rama Rao, S. V., Panda, A. K. and Sastry, V. R. B. 2007. Cottonseed Meal in Poultry Diets: A Review. *J. Poult. Sci.*, **44**: 119-134.
16. North, M. O. and Bell, D. D. 1990. *Commercial Chicken Production Management*. 4th Edition. Chapman and Hall, New York. 35-77
17. Park, S. Y., Birkhold, S. G., Kubena, L. F., Nisbet, D. J. and Ricke, S. C. 2004. Effects of High Zinc Diets Using Zinc Propionate on Molt Induction, Organs, and Postmolt Egg Production and Quality in Laying Hens. *Poult. Sci.*, **83**: 24-33.
18. Reyns, G. E., Janssens, K. A., Buyse, J., Kuhn, E. R. and Darras, V. M. 2002. Changes in Thyroid Hormone Levels in Chicken Liver during Fasting and Refeeding. *Comparative Biochem. Physiol. Part B.*, **132**: 239- 245.
19. Ruzsler, P. L. 1998. Health and Husbandry Considerations of Induced Molting. *Poult. Sci.*, **77**: 1789- 1793.
20. Statistical Analysis System (SAS). 1997. *SAS User's Guide: Statistics*. SAS Institute, Cary, NC.
21. Vleck, C. M. 2001. Comparison of Corticosterone and Heterophil to Lymphocyte Ratios as Indicators of Stress in Free-living Birds. In: "*Avian Endocrinology*". Dawson, A. and Chaturvedi, C. M. (Eds), Narosa Publishing, New Delhi. PP. 401- 411.

ارزیابی روش های شیمیایی و غیرشیمیایی در تولک بری مرغ های تخمگذار تجارتنی به عنوان روش های جایگزین محرومیت از خوراک

س. کریمی، ف. خواجعلی و ح. ر. رحمانی

چکیده

در این آزمایش از ۱۰۸ قطعه مرغ تخم گذار سویه هایلاین W36 استفاده شد. تعداد سه تیمار که هر کدام به عنوان یک روش تولک بری اجباری بود، به صورت زیر اعمال گردید: (۱) روش مرسوم محرومیت از خوراک، (۲) تغذیه جیره تخم گذاری که به میزان ۳۵ درصد با تخم کامل پنبه رقیق گردید و (۳) استفاده از جیره حاوی ۵۰۰۰ قسمت در میلیون روی به مدت ۲۸ روز که به مقدار ۵۰ گرم در روز به ازای هر پرنده تغذیه گردید. نتایج آزمایش نشان داد که تولید تخم مرغ در تیمارهای ۱، ۲، و ۳ به ترتیب در روزهای ۶، ۷ و ۱۴ تولک قطع گردید. محرومیت از خوراک باعث کاهش معنی دار (۰/۰۵) در وزن بدن و غلظت هورمون T_3 پلازما، ولی افزایش معنی دار (۰/۰۵) $P <$ در نسبت هتروفیل به لنفوسیت و هماتوکریت را موجب گردید. وزن تخم مرغ در پرندگان تغذیه شده با جیره حاوی روی به طور معنی داری (۰/۰۵) $P <$ بیش از سایر تیمارها بود ولی از لحاظ مقدار تولید روزانه و توده ای تخم مرغ، ضریب تبدیل خوراک و خصوصیات کیفی تخم مرغ در دوره بعد از تولک اختلاف معنی داری بین تیمارهای مختلف وجود نداشت.