

Effects of force molting on eggshell colour, egg production and quality traits in laying hens

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SUMMARY

The objective of this study was to explore the effects of force molting on eggshell colour, egg production and quality traits in brown laying hens. Lohmann Brown Classic adult hens were randomly divided into 2 groups: the molted group (n = 38) was submitted to a 10 day long molt period (consuming only alfalfa) whereas control hens (n = 36) were fed with a standard layer diet during the whole experimental period. Eggs in pre-molt (4 weeks) and post-molt (12 weeks) periods were examined for egg production, quality traits and eggshell colours. Force molting induced significant weight loss in hens. Egg production was dropped since the 5th day of the molt period and started again at the 3rd week of the post-molt period for reaching initial egg production. Whereas no difference was evidenced between the 2 groups during the pre-molt period, the eggshell strength as well as the red chromaticity and the yellow chromaticity were significantly increased in eggs from the molted hens during the post-molt period. These results suggest that a molt period may improve some egg qualities.

Keywords: Laying hen, force molting, eggshell colour, egg production, egg quality, eggshell strength

RESUME

Effets d'une période de restriction alimentaire forcée chez les poules pondeuses sur la couleur de la coquille

L'objectif de cette étude a été d'explorer les effets d'une période forcée de restriction alimentaire des poules pondeuses sur la production des œufs, leurs qualités et la couleur de la coquille. Des poules adultes Lohmann Brown ont été aléatoirement réparties en 2 groupes : le groupe « forcé » (n = 38) a été soumis à une période de restriction alimentaire de 10 jours (consommation exclusive de luzerne) alors que le groupe témoin (n = 36) a consommé un aliment standard pour poules pondeuses durant toute la durée de l'expérimentation. La production en œufs, les qualités des œufs et la couleur des coquilles ont été évaluées pendant 4 semaines avant et 12 semaines après la restriction alimentaire. Cette pratique a conduit à une perte de poids significative chez les poules. La production des œufs a considérablement chuté dès le 5^{ème} jour de la période de restriction et a repris 3 semaines après pour rejoindre le niveau initial de production. Alors qu'aucune différence entre les 2 groupes n'a été mise en évidence avant restriction, la résistance de la coquille des œufs issus de poules « forcées » ainsi que la chromaticité dans le rouge et dans le jaune ont été significativement accrues lors de la reprise de la ponte. Ces résultats suggèrent qu'une période de « forçage » peut améliorer certaines qualités des œufs.

Mots-clés : poule pondeuse, restriction alimentaire forcée, couleur de la coquille, production d'œufs, qualité des œufs, résistance de la coquille.

Introduction

Force molting is a practice that has been used by the commercial egg industry to rejuvenate flocks for extending laying cycle and restoration of egg quality. The main objective of force molting is to cease egg production of hens and that they enter a non-reproductive state [37]. There are several force molting methods. Feed withdrawal has been widely used in recent years due to its easy application, economic benefits and agreeable post-molt performance [7]. However, groups for the animal rights have recently been pressing for an end to force molting by feed withdrawal, claiming that feed withdrawal is highly stressful to the hen. For this reason, researchers have examined alternative force molting methods to feed withdrawal. These methods included high dietary zinc supplementation [2, 6, 31, 38], diets with low sodium contents [8], wheat middling [9], barley [27], cottonseed meals [10], jojoba meal [34], alfalfa [4, 12, 18, 21] and oat [3, 33], which have been successfully used for induced molting.

Brown-shelled eggs contain relatively large amounts of protoporphyrin-IX and relatively small amounts of biliverdin-IX [16, 32, 35]. Eggshell colour is determined by stress, disease and by the age of the hen [11, 22, 23, 25, 26]. Egg quality is important for commercial egg producers. As the hen age increased, egg weight was increased while shell strength, shell thickness, albumen height and Haugh unit decreased [1, 13]. Hens can be molted to induce another egg cycle, which will improve egg quality.

To the best of our knowledge, no previous studies have investigated force molting effect on eggshell colour. There have been many studies about the effect of force molting on egg production and quality, but not on eggshell colour. The hens are under stress during force molting, and this has a negative impact on eggshell colour. The purpose of this study was to produce information on the effects of force molting on eggshell colour, egg quality and egg production in brown laying hens.

Materials and Methods

ANIMALS AND MOLTING PROCEDURE

A total of 74 Lohmann Brown Classic laying hens, 69 week old, were obtained from The Research and Application Farm at the Faculty of Agriculture at Selcuk University (Konya, Turkey). Hens were placed one per cage (2000 cm²/hen), and 2 weeks were allowed for acclimation. During this time the hens were fed with a layer diet (Table I) and the photoperiod was 16 hours light / 8 hours dark. After the acclimation, the hens were divided into 2 groups with 36 and 38 hens per groups: non-molted (control, consuming layer diet during the molt period) and force molt (molted; consuming alfalfa during the molt period), respectively.

Hens were randomly assigned to cages to ensure there was no variability in egg production and quality. Hens were then molted for 10 days [4, 29]. All hens were allowed *ad libitum* access to water and their respective diets. Hens were placed on an artificial lighting programme of 8 hours light / 16 hours dark during the molt period [4, 12, 15, 21]. At the end of the molt, the lighting programme was changed to 16 hours light / 8 hours dark. The hens were weighed at the beginning (on day 0) and at the end of the molt period (on day 10) to calculate body weight loss.

EGGSHELL COLOUR, EGG PRODUCTION AND QUALITY PARAMETERS

Prior to molt, eggshell colour, egg weight, egg shape index, shell strength and egg production were measured over 4 weeks to confirm pre-trial uniformity between the control and molted groups. Eggshell colour and egg quality traits were measured weekly for all eggs produced on 5 consecutive days during each week from week 66 to week 69 (pre-molt period). Eggshell colour, egg weight, egg shape index and shell strength were measured on all eggs produced on 3 consecutive days every 2 weeks from week 3 to week 12 during the post-molt period. All eggs were collected over a 24 hours period. Prior to the measurement of egg quality, the eggs were stored for 1 day at room temperature (20 ± 2°C).

Eggshell colour was measured using a Minolta Chroma Meter CR-400 (Minolta, Osaka, Japan). The L*, a* and b* colour measurements were determined according to the CIELab colour space system, where L* corresponds to dark/light chromaticity (measured on a scale of 0% dark, to 100%, light), a* to green/red chromaticity (on a scale of -60% green, to 60% red) and b* to blue/yellow chromaticity (on a scale of -60% blue, to 60% yellow). The instrument was calibrated with a white reference tile (L* = 97.10, a* = -4.88, b* = 7.04) before the measurements were made [14]. The eggshell colour was measured at the large pole of the egg.

Ingredients (%)

Yellow corn	57.60
Soybean meal (48.0% CP) ¹	18.20
Sunflower meal (36.0% CP) ¹	5.40
Barley	6.00
Limestone	9.50
Dicalcium phosphate	1.20
Salt	0.30
VPM	0.25
DL methionine	0.05
Vegetable oil	1.50

Calculated nutrients

CP (%)	16.05
ME (kcal/kg)	2737
Ca (%)	3.61
Available P (%)	0.34
Lysine (%)	0.75
Methionine + Cystein (%)	0.60
Threonine (%)	0.60
Tryptophan (%)	0.18

¹analyzed value; CP: crude proteins; VPM: vitamin mineral premix supplying per kg of diet Vitamin A, 8 000 IU; Vitamin D₃, 2 200 IU; Vitamin E, 13 IU; Vitamin K₃, 2.67 mg; vitamin B1, 2.5 mg; vitamin B2, 4.67 mg; Vitamin B₆, 3.33 mg; Vitamin C, 33.0 mg; Calcium-D-Pantothenate, 6.67 mg; Nicotine acid, 17.0 mg; D-Biotin, 0.03 mg; Folic acid, 0.67 mg; Vitamin B₁₂, 0.01 mg; Cu, 5.0 mg; Fe, 60.0 mg; Mn, 100.0 mg; Zn, 60.0 mg; Se, 0.15 mg; Co, 0.50 mg; Choline, 125.0 mg; ME: metabolizable energy.

TABLE I: Composition of the layer diet.

Egg production and mortality were recorded daily throughout the pre-molt, molt and post-molt periods. Egg production and quality were determined from week 3 to week 12 after molting because there were no significant differences in egg production (hen-day, %) between control (82.38%) and molted (82.14%) hens at the 3rd week of the post-molt period.

Egg weight was measured using an electronic digital balance and was recorded to the nearest 0.01g. Shell strength (kg) was measured with an Egg Force Reader (06-UM-001, Version B, Orka Food Tech. Ltd., Hong Kong, China). The length and width of eggs were measured with a micrometer caliper (accuracy 0.01 mm, Mitutoyo Corp., Japan). Egg shape index was calculated using the formula: egg shape index (%) = 100 x (egg width / egg length).

STATISTICAL ANALYSIS

Before statistical analysis, the data were checked for normality and were found to be normally distributed, except for the body weight loss. Furthermore, data of body weight loss transformation was not helpful. Therefore, the Kruskal-Wallis test, a non parametric procedure, was used to test for the significance of differences in body weight loss between the groups. Eggshell colour, egg production, egg

	Control	Molted	p
Body Weight on day 0	1674 ± 31	1717 ± 30	NS
Body Weight on day 10	1711 ± 30 ^a	1343 ± 29 ^b	< 0.001
Weight variation (%) ¹	+1.4 ^a	-21.1 ^b	< 0.001

NS: not significant; ¹: expressed as median

Different superscripts a,b in the same row indicate significant difference (p < 0.05 or more) between groups.

TABLE II: Growth variations during the 10 days long molt period in laying hens. Results are expressed as mean ± standard error of the mean (SEM).

Parameters	Pre-molt period			Post-molt period		
	Control	Molted	p	Control	Molted	p
Egg production (%)	74.16 ± 1.67	76.23 ± 1.67	NS	75.46 ± 2.57	68.98 ± 2.56	NS
Egg weight (g)	61.67 ± 0.69	62.97 ± 0.67	NS	63.97 ± 0.71	65.86 ± 0.69	NS
Egg shape index	77.02 ± 0.38	77.18 ± 0.37	NS	76.68 ± 0.38	77.51 ± 0.37	NS
Egg shell strength (kg)	3.77 ± 0.08	3.87 ± 0.08	NS	3.47 ± 0.10 ^a	4.04 ± 0.10 ^b	< 0.001
Egg shell colour						
L*	66.24 ± 0.71	65.29 ± 0.69	NS	66.68 ± 0.65	65.05 ± 0.64	NS
a*	14.12 ± 0.51	14.91 ± 0.50	NS	13.48 ± 0.46 ^a	15.05 ± 0.45 ^b	< 0.05
b*	28.61 ± 0.30	29.37 ± 0.29	NS	28.22 ± 0.31 ^a	29.45 ± 0.29 ^b	< 0.05

NS: not significant; L*: light-dark chromaticity; a*: green-red chromaticity; b*: blue-yellow chromaticity.

Different superscripts a,b in the same row indicate significant difference (p < 0.05 or more) between groups.

TABLE III: Egg production, egg quality traits and eggshell colour values in control hens and hens molted for 10 days during the pre-molt (4 weeks) and post-molt (12 weeks) periods. Results are expressed as mean ± standard error of the mean (SEM).

weight, egg shape index and shell strength were analysed via general linear model (GLM). A least significant difference (LSD) test was applied to detect statistically significantly different groups. All data are expressed as least square mean ± standard error of the mean (SEM), except body weight loss. All analyses were carried out using Minitab (Version 14, Minitab Inc., State College, PA). Differences were considered as significant when p value was less than 0.05.

Results

No death was observed in control and molted hens during the molt and the post-molt periods. At the end of the molt period, molted hens exhibited a significantly lower body weight than the controls (p < 0.001) and they have significantly lost weight (p < 0.001): the weight loss reached 21.1% (median) whereas the control hens gained 1.4% of body weight during the same period (Table II).

As shown in the figure 1, the egg production significantly declined in the molted group compared to the control group since the 4th day of the molting period and was completely abolished on day 8. Molted hens started again to lay during the 2nd week of the post-molt period and returned to their initial egg production during the 3rd week. Thereafter the

egg production remained stable in this group whereas it gradually and significantly declined in the control group since the 9th week.

Regarding the pre-molt period, production, traits and colours of eggs from the control and the molted hens were similar (Table III). During the post-molt period, whereas egg production, egg weight and egg shape index have not significantly differed between the molted and control hens, the eggshell strength were significantly increased in the molted group (p < 0.001). As far as eggshell colours were concerned, it was observed that eggs from molted hens presented both higher a* (green-red chromaticity) and b* (blue-yellow chromaticity) values than the control eggs (p < 0.05, Table III) in the post-molt period, indicating strengthening in red and yellow colours, respectively.

Discussion

Induced molting is practiced to give the flock a rest at the end of a period of egg production [24]. Molted hens generally exhibited higher productivity, higher egg quality and low mortality compared to the control (unmolted) hens [2, 4, 12, 18]. Resting period (non-reproductive state) is important for an effective induced molt. NORTH and BELL [24] stated

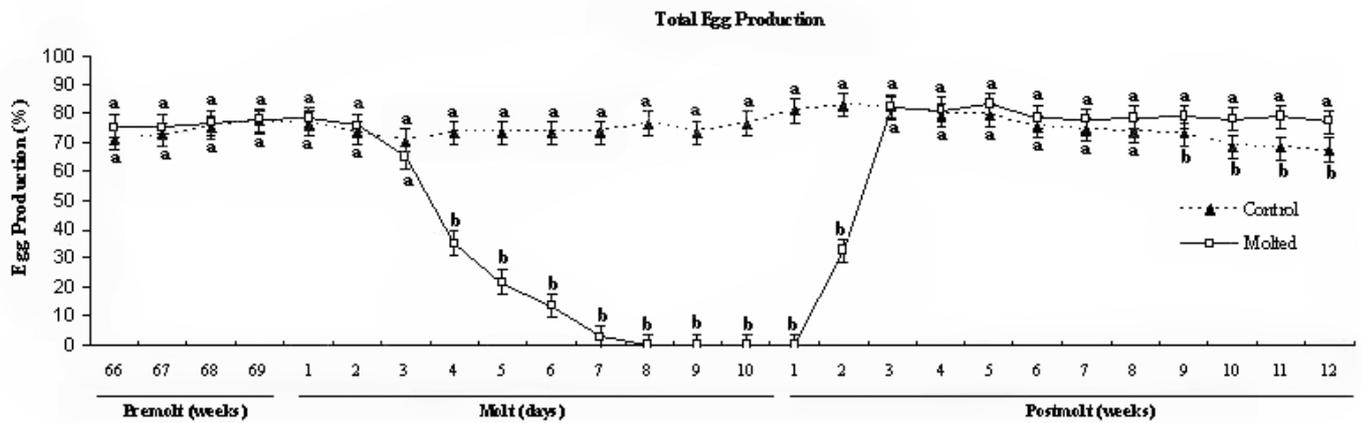


FIGURE 1: Hen day egg production (%) by molted and control groups on a weekly basis during the pre-molt, molt and post-molt periods. Least square means were significantly different with different letters between control and molted groups ($p < 0.05$).

that the earlier the hens enter the rest period and cease egg production, the quicker they will return to egg production and reach peak production. In the present study, the molted hens ceased egg production within the 4th-5th days of the molt period. Similar results were published by DONALSON *et al.* [12], who noted that molted hens with alfalfa ceased egg production within 5.25 days of the molt period.

In the present study, the body weight loss observed after a ten day long molt period is similar to values reported by AYGUN and OLGUN [4], LANDERS *et al.* [18], PETEK and ALPAY [28], who stated that body weight loss from hens fed with alfalfa was -18.9%, -19.54% and -20.83%, respectively. Body weight loss is directly related to the post-molt performance [5]. RUSZLER [30] stated that for optimum post-molt production, the body weight loss should be ranged between 15-40% during the molt period. Control hens gained 1.41% of body weight here and similar results were published by LANDERS *et al.* [18] and PETEK and ALPAY [28], who found that control hens gained 2.3% and 1.80% of body weight, respectively. Also, MAZZUCO and HESTER [20] stated that control hens did not lose body weight during the molt period. As expected, control hens have a higher hen-day egg production than molted hens at the 1st and 2nd weeks of the post-molt period (figure 1). In the weekly analysis of egg production, it appears that there were no significant differences in the post-molt egg production from the 3rd week to the 8th week between the molted hens and the control hens. However, after the 9th week in the post-molt period, the egg production was significantly higher ($p < 0.05$) in the molted group than in the control one. After the molt period, egg production and quality improve significantly compared to the pre-molt period [2]. In general, most researchers report that induced molting improves the postmolt performance of the laying hens compared to the pre-molt performance [12, 18].

During the post-molt period, hens in the molted group had similar egg weight and egg shape index as the controls. These results are consistent with other investigations on egg

weight [12, 17, 18, 28, 29] and egg shape index [28, 29]. In this study, eggs from molted hens exhibited significantly higher shell strength than eggs from unmolted hens ($p < 0.001$). This finding did not agree with results previously reported by DONALSON *et al.* [12] and PETEK *et al.* [29] who have obtained similar eggshell strength for eggs from control and molted (with alfalfa) hens. At the end of the laying cycle, the egg production and quality decline significantly, leading some producers to induce a molt in the flocks in an attempt to improve performance [2]. As eggs increase in size with age, shell strength will decrease [1, 36]. Cracked or broken eggshells account for 80 to 90% of the eggs that are routinely downgraded. The eggshell serves to contain the egg contents, but it is also the first barrier against bacterial penetration and must be free from defects in order to optimise the safety of the contents for human consumption [19].

Shell L^* value might be used to express whether the colour of the eggshell was dark or light and could be considered as a discriminative colour criterion: more the shell L^* value decreases, more the egg shell colour is darker. The result of the study showed that molt period did not negatively or positively influence eggshell L^* (darkness) during the post-molt period. By contrast, it was observed in the present study that the eggshell a^* and b^* values were significantly increased in the post-molt period compared to the control eggs, indicating that red and yellow colours were exacerbated. To the best of our knowledge, no previous studies investigated the effect of molt on eggshell colours (darkness, green-red chromaticity and blue-yellow chromaticity).

As a conclusion, the objective in the current study was to determine the effect of force molting on eggshell colour, egg quality and egg production. Force molting did not influence eggshell L^* (darkness) during the short-term postmolt period but significantly strengthened red and yellow aspects. On the other hand, force molting has positively influenced eggshell strength. Further studies are needed to determine the effects of force molting on eggshell colour in a long-term post-molt period.

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