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Evaluation of Some Methods of Forced-Moulting of Laying Birds and Their Effects on Post-Moult Performance and Quality Characteristics of the Post-Moult Eggs

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Abstract: Fifty 70 week old brown egg layers were randomly distributed into 5 groups each of 2 replicates of 5 birds each and subjected to some modalities of nutritional deprivation to evaluate the efficacy of such feeding manipulations, to induce moult and their effect on post moult production and some quality parameters of such eggs. The feeding regimens consisted of Feed and Water Deprivation (FWD), Feed Deprivation (FD), Water Deprivation (WD) and feeding zinc in a wheat offal diet. Result revealed that FD treatment before returning the birds to full feeding, was the most effective in inducing moult, followed by the zinc treatment. FWD and WD treatments showed lower degrees of moulting effectiveness, with the WD treatment being the least effective. The moult feeding treatments caused the birds to loose their pretreatment body weights. WD caused the highest body weight loss of 19.35%, followed by zinc and the FD treatments, which caused 16.88 and 15.88% body weight loss,respectively. FD treatment caused the highest percentage body weight recovery (BWR) at 1st egg post moult and made the highest body weight gain at 6 weeks, while the zinc group lost body weight at 6 weeks post moult. WD and FWD groups resumed egg production on 17th and 18th days respectively post the moult feeding treatments, while the zinc and FD groups resumed production on the 19th and 21st days, espectively. FD group was the first to reach 50% production and had the highest total egg production post moult, while zinc, FWD and WD groups reached 50% production on the 3rd, 4th and 6th days respectively post moult. Overall, it was concluded that depriving layers of feed, as in this study, before returning them to full *ad libitum* feeding, proved the most effective in inducing moult, increasing egg production post moult, improving egg weight and post moult body weight at 6 weeks compared with the other treatments in the experiment. However, in terms of egg haugh unit value, it was not as good as the birds previously deprived of water before returning them to feed and water *ad libitum*, as applied in this study.

Key words: Laying hens, feeding regimens, forced moulting, post moult production, egg quality characteristics

INTRODUCTION

Moulting or shedding of feathers, is a process, which members of the avian species go through. The laying hen goes through this process, almost as a ritual, at the end of the production cycle. The process is usually accompanied by caesation of egg production. However, some persistent layers may lay a few eggs while still going through the moulting process. The duration of the moult may vary with the flock or strain of the birds.

Laying hens going through a moult lose appetite during the process and this may result in Body Weight Reduction (BWR), which Mrosovsky and Sherry[1] tribute to ovarian and oviductal regression, loss of alimentary canal content and reduced water intake.

Laying hens can be made to go into a moult by subjecting them to undue stress, such as starvation or water deprivation for an extended period. Subjecting laying hens to stress in this manner, even in the midst of the production period, may induce a moult. Application of certain drugs and medicaments can also induce moulting in layers. These artificial methods constitute forced moulting. Ewing[2] ports that forced moulting is brought about through a radical change in the bird's environment. In the temperate region, this practice is sometimes used to ensure that hens take a vacation from laying, so

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that egg production can resume by early autumn when egg price is most favourable. Post moult eggs are believed to have better shell quality as well as improved haugh unit value-attributes which are associated with high quality eggs.

Moulting appears to be nature's way of getting the laying hen to rest and become rejuvenated. The nature and mechanism of its occurrence have been adequately studied. Knandel[3], reports that a fowl has ten long wing feathers known as primary feathers, which are located on the outside of the opened wing. Between the primary feathers and another group of large feathers called the secondary feathers, is the axil feather. The primary feathers normally moult in a definite order beginning with the feather next to the axil feather and continue to the tip of the wing. The number of feathers dropped at a time and the rate at which these are dropped, marks the difference between a good and a poor layer. The author reports that early moulters are poor layers and drop one primary feather at a time, at intervals of approximately two weeks. Allowing 6 weeks for the first new primary feathers to mature and 2 weeks for each additional new primary feather to fully mature, 24 weeks would be needed for the fowl to grow a complete new set of 10 primary feathers. As such, early moulters cannot lay a large number of eggs since they spend so much time in the moulting process. Late moulters on the other hand, are good moulters as they drop their primary feathers in clusters of two, three or more at short intervals or even carry some primary feathers over to the next production cycle. If a hen drops her ten primary feathers in clusters of 5 and each cluster is dropped one week apart, it would take about 7 weeks to complete the wing moult, which makes such a hen a rapid moulter and a high producer. Late moulters may even moult and lay at the same time. The purpose of this study was to evaluate the effectiveness of some forced moulting methods and compare the effects of such methods on post moult performance and the quality characteristics of such eggs.

MATERIALS AND METHODS

This study was carried out at the poultry unit of the Teaching and Research Farm of the University of Uyo, located in the South east region of Nigeria. Uyo has a humid tropical climate with an annual rainfall of between 2550 and 4000 mm, a relative humidity of 60-80% and an average environmental temperature of 27-38°C, which is typical of most of this region.

Birds and management: Fifty 70-week old brown egg type layers were used in the experiment, which was essentially a completely Randomized Experimental Design. These birds, which had been in lay for 48 weeks, were randomly divided into 5 groups of 10 birds per group, each of which was sub-divided into two replicate groups of 5 birds each and each replicate housed in an improvised battery cage constructed with wood and hard wire netting with each cage compartment measuring 1 m x 0.7 m x 0.75 m. The birds were given a common proprietary layer diet *ad libitum* for 7 days to acclimatize them before they were subjected to the moult feeding regimen. The composition of the proprietary layer mash is as follows: Crude protein, 16.00%, Metabolizable energy 10.88MJ, Calcium 3.25, Phosphorus 1.00, Fibre 4.00 and Oil 3.00%. The same diet was used throughout the experiment.

The following moult feeding regimens were applied to the respective groups.

Treatment 1: (Control) normal feeding with water *ad libitum*

Treatment 2: (FWD) Deprived of feed and water for 3 days, then fed wheat offal for 7 days before returning them to normal layer mash *ad libitum.*

Treatment 3: (FD) Deprived of feed but not water for 7 days, then fed wheat offal for 7 days before returning them to normal layer mash ad libitum.

Treatment 4: (WD) Deprived of water but not feed for 7 days; before returning them to normal layer mash ad libitum

Treatment 5: (Zinc) Fed wheat offal containing 2% Zinc as Zinc sulphate for 7 days; thereafter returned to normal layer mash ad libitum.

Data collection: After the acclimation period, the initial body weights of the birds were taken. The birds were also weighed at the end of the moult feeding treatment, at 1st egg, at 6 weeks post moult.

The following data were also collected:

- Number of days it took the different groups to cease production following the moult diet.
- Degree of moulting (by visual scoring)
- Number of days to 1st egg post moult
- Number of days to 50% production post moult
- Total production per treatment
- Shell quality
- Weight of eggs from different treatment groups
- Wet and dry egg shell weights

- Yolk height, albumin height, yolk diameter and albumin diameter

The yolk and albumin values were used to calculate albumin index, yolk index and haugh unit value, using the conventional formula:

$$\text{Haugh Unit (HU)} = 100\log (A_H - 1.7W_E^{0.37}) + 7.5$$

Where A_H is Albumin Height in millimeters
W_E is Weight of egg in gms.

Data collected on production, body weight, egg weight and shell weight were subjected to analysis of variance procedure (ANOVA) according to Snedecor[4]. Means between values were separated using Duncan's Multiple Range Test as modified by Steel and Torrie[5] at 5% probability. In addition, observations and measurements were made of the shell gland as affected by the treatments. For this purpose, two birds were randomly removed from each treatment group and the control at the end of the experiment and killed by cervical dislocation as described by Bremmer[6]. Each of the birds so killed was submerged in hot water to loosen the feathers. After plucking, each carcass was opened up and the oviduct particularly the shell gland, cut out and weighed, using the Mettler Toledo sensitive electronic balance and examined to assess the degree of involution, thickness and folds, where present, as affected by the treatments.

RESULTS

Degree of moulting: The quantum of shed feathers observed to have gathered under the cage of each treatment group, was used to visually score the treatments for their effectiveness. Hens deprived of feed only (FD) as a moult inducer, showed the highest degree of moulting. (+++++) This was followed by the zinc in wheat offal treatment group (++++). The water (WD) deprived group and the Feed and water (FWD) deprived group showed reduced levels of moulting (+++ and ++, respectively). These degrees of moulting effectiveness were consistent with the quantum of feathers under the cages of the different bird groups.

Body weight dynamics following moult treatment: As expected, the moult diets fed to the different groups did not meet their body nutrient requirement. As such, this resulted in Body Weight Reduction (BWR), the pattern of which is shown in Table 1.

All the moulted birds in the experiment recovered from their body weight losses following return to full ad libitum feeding. There were however no significant differences ($p<0.05$) between the various treatments in the group weight dynamics

Number of days to cessation of egg production following moult treatment, number of days to resumption of production and number of days to 50% production post-moult: Following application of the different treatments to induce moult, laying came to a stop. Hens deprived of Feed and Water (FWD) and the zinc treated groups both ceased production on the 3rd day of the moult feeding treatment, while the Feed Deprived (FD) and the water deprived (WD) groups ceased production on the 4th and 5th days, respectively. The Water Deprived group (WD) resumed laying on the 17th day post moult, while the Feed and Water Deprived (FWD), zinc fed group and the Feed Deprived (FD) groups resumed lay on the 18th, 19th and 21st days post moult, espectively. Attainment of 50% production post moult was on 1st day for the Feed Deprived (FD) group, 3rd day for zinc group, 4th day for the Feed and Water Deprived (FWD) group, while the Water Deprived (WD) group took the longest period of 6 days to attain this production level.

The effect of the treatment on haugh unit value shows that each of the moulted groups had higher haugh unit values than the control, with water deprived treatment having the highest haugh unit value of 91. Feed and Water Deprived (FWD) and the zinc groups were similar (74;75) while the Feed Deprived (FD) group was the least in haugh unit value among the moulted groups (51).

Effect of moult treatment on egg production, egg weight and egg shell weight: Egg weight and egg shell quality are perhaps the most important aims of a moult treatment exercise. Table 2 shows the effect of the different forced moulting treatments in this experiment, on egg production, egg weight and egg shell weight post moult. Egg production by the Feed Deprived (FD) group was significantly higher ($p<0.05$) than those of the Feed and Water Deprived (FWD), Water Deprived (WD) and zinc fed hens, but not significantly better ($p>0.05$) than the control. Although egg production by the control group was numerically higher, it was not significantly better ($p>0.05$) than those of the Water Deprived (WD) and the zinc fed hens.

The 1st egg post moult from the Feed Deprived (FD) hens had significantly higher egg weight value than that of the control group ($p<0.05$) while eggs from zinc fed birds and the Feed and Water Deprived (FWD) groups were statistically similar and significantly higher than those from the Water Deprived (WD) hens ($p<0.05$). At 6

Table 1: Effect of moult treatment on mean body weight dynamics

Parameter	Treatment: Control	Feed and water deprived	Feed deprived	Water deprived	Zinc in wheat offal
Pre-moult treatment weight (kg)	1.55	1.46	1.52	1.55	1.54
Post-moult treatment weight (kg)	1.57	1.26	1.28	1.25	1.28
Absolute weight loss (kg)	-	0.20	0.24	0.30	0.26
% Body weight loss	-	13.70	15.80	19.35	16.88
% Body weight recovery at 1st egg	-	18.25	20.31	17.60	15.63
Body weight at 1st egg post moult (kg)	1.57	1.49	1.54	1.47	1.48
Body weight at end of expt (kg) 6 wks	1.58	1.50	1.64	1.55	1.49
Absolute weight gain (kg) at 6 wks	0.30	0.40	1.20	-	-0.50
% Body weight gain at 6 wks	1.94	2.74	7.80	0.00	-3.25

Means in the same row bearing the same or no superscripts are not significantly different (p<0.05)

Table 2: Effect of moult treatment on egg production, egg weight and egg shell weight post moult

Parameter	Treatment: Control	Feed and water deprived	Feed deprived	Water deprived	Zinc in wheat offal
Egg production (%) pre-treatment	38.50 ± 1.161^{ab}	28.00 ± 1.09^{ab}	42.33 ± 1.96^{a}	34.50 ± 2.45^{b}	33.83 ± 2.45^{b}
Egg weight (g) pre moult treatment	54.77 ± 0.34^{ab}	55.53 ± 1.37^{ab}	50.60 ± 1.16^{a}	55.59 ± 1.32^{a}	52.22 ± 1.25^{c}
1st egg post moult	54.24 ± 1.15^{b}	52.63 ± 1.28^{bc}	59.01 ± 0.74^{a}	47.30 ± 0.66^{cd}	54.21 ± 0.65^{bc}
6 weeks post moult	56.63 ± 0.80^{c}	59.61 ± 0.26^{ab}	60.56 ± 0.24^{a}	56.75 ± 0.32^{c}	58.85 ± 0.29^{b}
Egg shell weight (g) wet shell weight	6.15 ± 0.11^{a}	6.19 ± 0.17^{a}	6.22 ± 0.10^{a}	6.18 ± 0.16^{a}	6.47 ± 0.9^{a}
Dry shell weight	5.65 ± 0.05^{ab}	5.59 ± 0.14^{ab}	5.28 ± 0.22^{b}	5.69 ± 0.07^{a}	5.54 ± 0.29^{ab}

Means in the same row bearing similar superscripts are not significantly different (p<0.05)

Table 3: Effect of moult treatment on the weight and morphology of the shell gland

Parameter	Treatment: Control	Feed and deprived water	Feed deprived	Water deprived	Zinc in wheat offal
Mean weight (g)	15.19^{b}	15.10^{b}	15.11^{b}	15.84^{a}	10.49^{c}
Shell gland Thickness as felt					
On palpation	Thick	Thin	Thin	Thick	Very Thin
Mucosal folds	Numerous Less dense	Less Numerous	Numerous	Less Numerous	Less Numerous

Means in the same row bearing the same superscripts are not significantly different (p<0.05)

weeks post moult, Feed Deprived (FD) and Feed and Water Deprived (FWD) hens had similar egg weight values which were statistically higher than the control ($p<0.05$). However, the control and the Water Deprived (WD) hens were similar in this respect. The zinc fed and the Feed and Water Deprived (FWD) hens were statistically similar.

Egg shell weight is a function of calcium in the shell structure. There were no significant differences in the wet shell weight of the different treatment groups ($p>0.05$). However, small variations existed in the dry shell weight values but these were not significant. The data in this respect are shown in Table 2.

Effect of moult treatment on the morphology of the shell gland: The effect of the moult treatments on the morphology of the shell gland is presented in Table 3. The mean weight value of the shell gland was highest in the Water Deprived (WD) hens. This was followed by those of the Feed Deprived (FD) and water and feed deprived (FWD) hens, both of which were statistically similar. The shell gland weight of the zinc fed hens was the lowest and significantly below the shell gland weight values of the other three treatment groups and also of the control.

Although physical thickness measurements of the wall of the shell glands were not taken, there were obvious and palpable differences between the treatments and the control. The Water Deprived (WD) group and the control exhibited about the same degree of palpable thickness with numerous mucosal folds although the folds were less dense in the control group. The shell glands of the other treatment groups were thin.

DISCUSSION

Moulting is a natural phenomenon among the avian species. The laying hen goes through this process at the end of the production cycle. Despite intensive domestication, breeding and selection over the years, the laying hens still exhibit the moulting characteristic. It thus appears that this process is nature's way of getting the laying hen to rest after a production cycle, so as to rejuvenate the hen and prepare it for the next production cycle. Smith[7] asserts that the process is initiated by hormones beginning with increased production of the thyroid hormone- thyroxin. Moulting can also be initiated by a decrease in day length or by stress caused by depriving birds of water or feed. The process leads to complete caesation of egg production, although some good and persistent layers may lay a few eggs while still undergoing the moult by Knandel[3].

The effect of moulting is beneficial to the commercial egg producer because of the attributes associated with post moult production and its egg quality characteristics. Within the body system of the bird, the physiological mechanism of the bird's productive process also seems to be benefited, resulting in the laying of better quality eggs post moult. Force moulting the laying hen appears to hasten the productive and reproductive stress, so that at resumption of production, the physiological functions associated with production are enhanced. This includes albumin delivery in the reproductive system, thus resulting in improved haugh unit value of post moult eggs. There also appears to be optimum activities of the shell gland in delivering calcium for shell formation, which results in improved shell quality of post moult eggs.

Hens undergoing natural moult take a considerable time to complete the moult process, which results in reduced egg production. In the temperate region, during the fall (autumn), there is usually an increase in the market price of eggs due to shortfall in production. Winter and Funk[8], report that it was on the basis of this that the idea of forced moulting of layers was born some years back in the USA, with the aim of taking advantage of the favourable egg price during the fall when majority of layers are undergoing natural moult and are laying at a low rate. These authors report that forced moulting is a rapid means of effecting a change in the birds productivity through a radical change in their environment.

In the present study, much light was shed on some of the changes, which surround the physiology of moulting, in the following areas:

Body weight reduction: The different moult treatment applied in the experiment amounted to interference in the birds' nutritional requirement and this resulted in body weight reduction in the different treatment groups. The significant body weight loss and the resultant caesation in egg production experienced by the different treatment groups (Table 1), may be as a result of ovarian and oviductal regression, loss of alimentary canal contents as well as reduced water intake resulting from the stress. This observation agrees with the report of Mrosovsky and Sherry[1], who observed that body weight reduction during moulting was due to various organ weight losses. Moreso, body weight loss which occurred following moult treatment, may be partly due to tissue waste following deprivation, because the different moult feeding regimens and manipulations applied to induce moult, amounted to starvation or nutrient deprivation, which invariably had adverse effect on body weight. Secondly, body weight loss in the moulted hens could be due to negative nitrogen balance following the period feed was deprived, which is consistent with the effect on feed deprivation as reported by Buhr and Cunningham[9], Berry and Brake[10] and Bell and Kunney[11]. Birds deprived of Water (WD) but not feed for 7 days and thereafter returned to feed and water ad libitum had the highest body weight loss of 19.35%. This may be attributed to the birds having to resort to water present in the feed and their body water reserve for normal metabolism. Consequently, such birds suffer water deficit and loss of body weight,[2,12,13].

Body weight recovery and body weight gain: Body weight recovery and body weight gain are two almost inseparable characteristics. Sometimes it may be difficult to determine the threshold between the two. Body weight recovery is essentially that part of body weight mass generated to bring the body weight back to the level it was prior to the weight reduction occasioned by the moult treatment. It is from there that body weight gain may be discerned. All the moulted hens in this study recovered from body weight loss. The rate or the percentage of body weight recovery was, however, variable as shown in Table 1. Following realimentation, protein and other nutrients were made available to create a conducive environment for tissue regeneration and body weight recovery. The lowest body weight recovery was in the birds fed zinc in wheat offal diet, which may have been due to the effect of zinc, which Smith[7], has associated with weight reduction in young birds, Birds deprived of feed but not water for 7 days, followed by wheat offal diet for another 7 days, before returning them to normal layers mash ad libitum, made the highest percentage body weight recovery. This may be because water was not withheld, so the birds did not suffer water deficit which would have seriously impaired body function and the recovery of lost weight. Various other factors may have contributed to the differences in the rate or percentages of body weight recovery recorded in this study. These may include intrinsic ability of the individual hens to withstand stress and the severity of the moult treatment methods applied.

Egg production: Knandel[3], had observed that when a hen is in full moult, it seldom lays. However, some good and persistent layers may still lay a few eggs while still moulting. The author observed further that early moulters are poor layers because they spread the moult process over a prolonged period of time during which they don't lay. Normally, hens in the 2nd year production cycle lay 20% less eggs compared with their pullet year production (Bell,[14]). Result in the present study demonstrates that inducing moulting by depriving birds of feed but not water for 7 days, followed by feeding wheat offal for another 7 days before returning them to full feed ad libitum, resulted in a higher egg production post moult, compared with other treatments in the experiment. In comparison, the number of eggs laid by the non moulted control group was less than the production of the (FD) group (Table 2), although the difference was not significant ($p>0.05$). The Feed Deprived (FD) group also had a higher egg production than the Feed and Water Deprived (FWD) group, while the (WD) and the zinc group were similar to the control.

Egg size: Post moult egg size has been reported to be larger than pre-moult egg size[14,15]. In the present study comparison was made with eggs of the birds in the control group which were not moulted and at 6 weeks post moult, to allow the moulted birds adjust to production. The post moult egg sizes were significantly higher than those of the control, except the eggs of the (WD) hens which were similar to the control in this respect. The hens in this treatment had suffered water deficit which probably affected their egg size which needed time to adjust.

The value of large egg size in the marketing system lies in the premium price which such eggs may attract. In this experiment, birds induced to moult by depriving them of water but not feed for 7 days, followed by feeding wheat offal for another 7 days before full realimentation, exhibited a significant increase in egg size both at 1st egg and at 6 weeks post moult. This result is consistent with the observation of Bell[14] and Koelkebeck *et al.*[15], who reported that post moult eggs were usually larger than pre-moult egg sizes. However, of the other moulted groups, only the (WD) hens did not measure up to the control in this respect, at first egg post moult.

Shell quality: Egg shell quality is of economic importance to the commercial egg producer because poor shell quality can cause considerable loss since such eggs break easily during handling and transit. Variations may, however, occur in egg shell quality from birds of different ages and declining egg shell quality in ageing hens may be a consequence of impaired calcification which may be a manifestation of reduced calbindin expression in the calcium transport system. Calcium and phosphorus must be mobilized in the uterus or shell gland of laying hens for proper shell formation.

Forced moulting seems to enhance reproductive rest and could be a way of facilitating calbindin synthesis in laying hens for proper shell formation. The rest enables the system to recover from the stress of production so that at resumption of lay, the functions associated with the production of high quality eggs are restored. These include, in addition to calbindin expression, delivery of albumin to ensure high haugh unit value, which is an important attribute of egg quality.

Calbindin-D_28k or simply calbindin, is the vitamin D dependent calcium binding protein present in relatively large quantities in the avian duodenum (Wasserman and Taylor,[16]) and in the uterus or shell gland of laying birds (Fullmer *et al.*,[17]). The function of vitamin D in this regard has been revealed by Wasserman and Taylor[16], to have the specific role of evoking the synthesis of a special calcium binding protein which carries calcium across the mucosa at the brush borders of the intestines of laying hens, without which egg shell is poorly formed. The improvement in egg shell quality following moulting may be due to improved, restored or increased calbindin expression which the authors have associated with improved egg shell quality. However, in this study, there were no significant differences in the shell quality of eggs of birds from the different treatment groups compared with the control. This may be because the birds in the experiment needed more time to recover from the effect of the moult treatments, which probably hindered the synthesis of calbindin. Secondly, the short duration of feed deprivation of less than 10 days may be responsible for the non-significant difference in the egg shell weight values, which is consistent with the observation of Koelkebeck *et al.*[15], who reported that satisfactory egg shell quality was enhanced by using fasting periods of 10 days or longer as a moult inducer.

CONCLUSION

In this study, the Feed Deprived (FD) treatment, as a moult inducer, was the best among all the methods employed. Hens exposed to this treatment were the best moulted, judged by the quantum of feathers dropped. This group of hens had significantly higher egg production and egg weight post moult when compared with other moulted groups. At 1st egg and at 6 weeks post moult, this group also exhibited the highest percentage body weight recovery as well as body weight gain, which probably enhanced higher production. There were, however, no statistical differences in egg shell weight values, which may have been due to the short duration of the treatment which was not long enough to facilitate mobilization of the reproductive apparatus of the birds for such functions as synthesis and delivery of calcium ions for shell improvement. Water Deprived (WD) hens produced the highest haugh unit value- an attribute which is the most widely used quality measurement of eggs (Hawthorne,[18]). On the whole, the (FD) treatment had the best overall result in terms of moulting effectiveness, body weight recovery, egg production, body weight gain and egg weight values, although it fell short in its haugh unit value.

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