Effect of Crude Protein Level and Refeeding Method of Postmolt Diet on Performance and Egg Quality in Layers after Forced Molting

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Effect of crude protein (CP) level and refeeding method of the postmolt diet on performance and egg quality in layers after forced molting was studied using 1,000 Single Comb White Leghorn layers. For a control group, another 60 layers did not undergo forced molting and were fed a layer diet (2.85 kcal ME/g and 17.3% CP).

Forced molting was carried out using only fasting and light control. Fasting was continued until the body weight (BW) of the layers decreased about 30%. The layers were then divided into four groups: the first group was fed a low CP diet (2.57 kcal ME/g and 14.3% CP) *ad libitum*; the second group, a low CP diet on a restricted feeding schedule; the third group, a high CP diet (2.85 kcal ME/g and 17.3% CP) *ad libitum*; and the fourth group, a high CP diet on a restricted feeding schedule. In the restricted-feeding groups, feed volume was increased gradually over 7 days, and then changed to *ad libitum*. Each group was fed the postmolt diet till egg production reached 5%, and then fed a layer diet.

The *ad libitum*-feeding groups had less accumulated mortalities than the restricted-feeding groups during the refeeding period. The layers fed the high CP postmolt diet tended to produce heavier eggs than those fed the low CP diet. Neither CP level nor feeding method affected egg production, egg mass, feed intake, or egg quality after refeeding. The maximum improvement in egg quality (compared with the control group) occurred at week 12 of the fasting period: egg shell strength increased 1.23 kg/cm²; haugh units, 10.7; egg shell thickness, 0.038 mm; and egg specific gravity, 0.006.

These results indicate that an estimated CP content of lower than 14.3% in a postmolt diet is adequate for layers and that *ad libitum*-feeding is better than restricted-feeding for low mortalities.

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Key words: postmolt diet, refeeding method, laying performance, egg quality

Introduction

Egg production rate and egg quality decline with advancing age of the laying hens (CUNNINGHAM *et al.*, 1960; ROLAND, 1979; BELL and ADAMS, 1992). Attempts to counteract this decline include forced molting which can be induced either by manipulation of specific nutrition (SHIPPEE *et al.*, 1979; BERRY and BRAKE, 1987; HUSSEIN *et al.*, 1989; DICKERMAN and BAHR, 1989) or by fasting and photo-control (ANDREWS *et al.*, 1987; HANZEN and YALCIN, 1988). Studies have demonstrated its success (ROLAND and BAKER, 1982; BAKER *et al.*, 1983; KOELKEBECK *et al.*, 1992; BELL and KUNEY, 1992).

The most popular forced molting method in Japan involves reducing the body

weight (BW) of layers older than 70 weeks. In this method, the layers are first put on a fast until their BW decrease 30%. The layers are then fed a low crude protein (CP) diet until their egg production reaches 5%, and then switched to a layer diet. However, no reports support feeding layers low CP diets. The recent improved genetic performance of commercial layers may require higher CP and metabolizable energy (ME) levels in the postmolt diet than current levels. Although the amount of postmolt diet supplied to a layer is generally increased gradually during the refeeding period, but this is difficult to implement in modern automatic feeding systems. Therefore, *ad libitum* refeeding during this post-fast period is preferable. Furthermore, because consumers demand high egg quality, the refeeding method and CP level must not have an adverse effect on egg quality.

The objective of this study is to clarify the effect of the dietary CP level and the refeeding method of the postmolt diet on laying performance, mortality, and egg quality in layers after a forced molting.

Materials and Methods

One thousand sixty Single Comb White Leghorn layers that were 66 weeks of age from our experimental farm were used in this experiment. On November 27, these birds had a 75% hen day egg production rate for 8 days prior and were housed in individual cages in a open house. Of these layers, 60 were used as the control group, which was fed the layer diet throughout the study and did not undergo forced molting. The other 1,000 layers were forced-molted under the feeding program and photo-control (Fig. 1) described by ANDREWS *et al.*(1987). After 24 hrs lighting for 7 days, lighting time was shortened to 12 hrs during the fasting period. After the fasting, 30 randomly selected hens were used as monitors ; They were weighed daily, and then fed the postmolt diet after they lost 30% BW. From day 28 to 84, The lighting time was increased gradually to 16 hrs a day.

Table 1 shows the composition of the experimental diets, which were formulated using practical feedstuffs. We used a low CP diet that contained 2.57 kcal ME/g, 14.3% CP and 2.5% calcium (Ca) ; a high CP diet that contained 2.85 kcal ME/g, 17.3% CP and 1.9% Ca ; and a layer diet that contained 2.85 kcal ME/g, 17.3% CP and 3.2% Ca.

At the end of the fasting period, the layers were divided into four groups of 250 each. During the refeeding period, the first group was fed the low CP diet *ad libitum* ; the second group, the low CP diet on a restricted feeding schedule ; the third group, the

Fig. 1. Program of forced molting of layers at 66 weeks of age. Following 30% loss of body weight after fasting, postmolt diet was fed and then changed to layer diet after reaching 5% egg production.

Table 1. Composition of postmolt and layer diets (%)

	Postmolt		Layer
	low CP	high CP	
Yellow corn	32.9	53.65	51.0
Grain sorghum	24.8	10.0	13.15
Raw rice bran		4.0	2.5
Defatted rice bran	13.1	5.1	
Wheat bran	5.0		
Soybean meal (45% CP)	4.1	15.7	3.9
Soybean meal (48% CP)			2.05
Rapeseed meal	5.0	2.5	4.0
Sesame meal			3.0
Safflower meal	3.1		0.5
Corn gluten feed	2.8		2.5
Corn gluten meal (60% CP)			4.45
Fish meal (60% CP)	1.0	2.0	1.0
Meat and bone meal (45% CP)	1.8	2.65	4.0
Animal fat	0.5	0.5	1.0
Salt	0.25	0.2	0.2
Calcium carbonate	5.52	3.58	6.58
DL-methionine	0.03	0.02	0.04
Paprika extract			0.03
Mineral-Vitamin premix	0.1	0.1	0.1
Calculated nutrients			
Metabolizable energy (kcal/g)	2.57	2.85	2.85
Crude protein	14.3	17.3	17.3
Calcium	2.5	1.9	3.2
Available phosphorus	0.32	0.35	0.36
Methionine+Cystine	0.56	0.65	0.65

high CP diet *ad libitum* ; and the fourth group, the high CP diet on a restricted feeding schedule. In restricted feeding, 20 g of postmolt diet was supplied to each layer on the first postmolt day and then increased 15 g every day thereafter. In *ad libitum* feeding, the postmolt diet was supplied *ad libitum* from the first postmolt day. When the hen day egg production rate reached 5% for a group, the group was fed the layer diet.

Egg production and egg weight were recorded daily and feed consumption biweekly. To determine the egg quality, from each group (including the control) we collected 30 eggs laid by the same hens, stored them in a refrigerator over night, and then weighed them. Egg specific gravity was measured using 11 kinds of copper sulfate liquid of various specific gravity, from 1.056 to 1.100 with the range of 0.004. Egg shell strength, egg shell thickness and albumin height were measured using instruments made by Fujihira K.K.. The Haugh unit was calculated using the measured egg weight and albumin height with the equation by HAUGH (1937).

Statistical significance was determined by analysis of variance and the significance of difference between means was assayed by Duncan's new multiple range test

(SAS Institute, 1985).

Results

It took 11 days for the fasting monitor hens to lose 30% BW and 17 more days to reach a 5% egg production rate. Table 2 summarizes the performance of layers. In the forced molted hens, egg production rate decreased from 75.0% at 66 weeks to 0% at day 6 of the fasting period. After refeeding, the rate increased linearly, reached a maximum 82.7% at 78 weeks, and then decreased to a minimum 69.2% by 96 weeks. In the non-molted layers (control group), this rate decreased gradually from 75.0% at 66 weeks to 61.9% at 96 weeks. Neither CP level nor refeeding method affected egg production, egg weight, egg mass or feed intake.

Accumulated mortalities (Table 2) in the *ad libitum* feeding groups were lower than in the restricted feeding groups. Effect of CP level on mortality was small.

Maximum improvement in egg shell strength in the forced molt groups occurred at 78 weeks (Table 3), after which it declined again at the same rate as the non-molted

Table 2. Effect of dietary CP level and refeeding method on performance of layers

	Low CP		High CP		Non-molted	Pooled SEM
	<i>Ad libitum</i>	Restricted	<i>Ad libitum</i>	Restricted		
Egg production ¹ (%)	70.6	69.6	67.1	69.3	68.0	1.56
Peak egg production (%)	82.7	82.2	77.9	81.8	—	
Egg production at 96 weeks	69.7	75.3	69.2	72.7	61.9	
Egg weight ¹ (g)	67.9 ^b	68.1 ^{ab}	68.6 ^{ab}	67.8 ^b	69.1 ^a	0.13
Egg mass ¹ (g/layer/day)	48.1	47.6	46.1	47.1	47.0	1.08
Feed intake ² (g/layer/day)	119.1	120.2	119.1	119.2	120.9	0.87
Accumulated mortality (%)						
at 69 weeks	0.35	2.25	0.69	1.03		
at 96 weeks	2.44	4.32	2.74	4.48		

^{a, b} Means within a row with no common superscripts are significantly different.

¹ Calculated from 71 to 96 weeks of age.

² Calculated from 69 to 96 weeks of age.

Table 3. Effect of dietary CP level and refeeding method on egg shell strength (kg/cm²)

Age (weeks)	Low CP		High CP		Non-molted	Pooled SEM
	<i>Ad libitum</i>	Restricted	<i>Ad libitum</i>	Restricted		
66	2.76 ^{ab}	2.72 ^{ab}	3.05 ^a	3.00 ^{ab}	2.67 ^b	0.06
75	3.68 ^a	3.54 ^a	3.36 ^a	3.54 ^a	2.68 ^b	0.06
78	3.87 ^a	3.50 ^a	3.66 ^a	3.67 ^a	2.64 ^b	0.07
80	3.51 ^a	3.26 ^a	3.46 ^a	3.62 ^a	2.53 ^b	0.06
82	3.16 ^a	3.01 ^a	3.19 ^a	3.17 ^a	2.14 ^b	0.07
84	3.21 ^a	3.08 ^a	3.07 ^a	3.20 ^a	2.31 ^b	0.07
86	3.22 ^{ab}	2.94 ^b	3.06 ^{ab}	3.45 ^a	2.47 ^c	0.07
90	2.84 ^{ab}	2.95 ^{ab}	3.25 ^a	3.01 ^{ab}	2.54 ^b	0.08

^{a, b} Means within a row with no common superscripts are significantly different.

group. The egg shell strength improved a maximum 20% compared with the strength at 66 weeks, which was before the fasting period. Compared with the non-molted group, The egg shell strength increased by a maximum 1.23 (3.87 : 2.64) kg/cm². Neither CP level nor refeeding method affected egg shell strength. Similar improvement

Table 4. Effect of dietary CP level and refeeding method on Haugh unit

Age (weeks)	Low CP		High CP		Non-molted	Pooled SEM
	<i>Ad libitum</i>	Restricted	<i>Ad libitum</i>	Restricted		
66	79.6 ^{ab}	76.7 ^b	80.7 ^a	79.4 ^{ab}	78.0 ^{ab}	0.6
75	79.6 ^b	80.5 ^{ab}	81.2 ^{ab}	82.8 ^a	70.5 ^c	0.7
78	84.6 ^a	81.5 ^b	81.4 ^b	86.1 ^a	75.4 ^c	0.6
82	78.9 ^b	79.0 ^b	82.3 ^a	79.8 ^b	71.4 ^c	0.6
86	83.3 ^{ab}	82.0 ^b	85.6 ^a	83.0 ^{ab}	69.3 ^c	0.9
90	82.1 ^a	79.4 ^a	82.3 ^a	82.1 ^a	68.0 ^b	0.9
94	77.8 ^a	80.0 ^a	77.5 ^a	78.0 ^a	68.0 ^b	0.7
99	78.2 ^a	72.9 ^b	78.1 ^a	75.1 ^{ab}	61.3 ^c	0.9

^{a, b} Means within a row with no common superscripts are significantly different.

Table 5. Effect of dietary CP level and refeeding method on egg shell thickness (mm)

Age (weeks)	Low CP		High CP		Non-molted	Pooled SEM
	<i>Ad libitum</i>	Restricted	<i>Ad libitum</i>	Restricted		
66	0.371	0.374	0.379	0.371	0.382	0.002
75	0.398 ^a	0.393 ^{ab}	0.388 ^{ab}	0.401 ^a	0.383 ^b	0.002
78	0.395 ^a	0.379 ^b	0.405 ^a	0.406 ^a	0.368 ^b	0.002
82	0.372 ^a	0.372 ^a	0.366 ^{ab}	0.373 ^a	0.355 ^b	0.002
86	0.375 ^a	0.371 ^{ab}	0.380 ^a	0.380 ^a	0.360 ^b	0.002
90	0.375 ^a	0.359 ^b	0.362 ^{ab}	0.364 ^{ab}	0.366 ^b	0.002
94	0.358	0.358	0.362	0.357	0.354	0.002
99	0.362	0.357	0.357	0.355	0.355	0.003

^{a, b} Means within a row with no common superscripts are significantly different.

Table 6. Effect of dietary CP level and refeeding method on egg specific gravity

Age (weeks)	Low CP		High CP		Non-molted	Pooled SEM
	<i>Ad libitum</i>	Restricted	<i>Ad libitum</i>	Restricted		
66	1.079	1.079	1.081	1.079	1.080	0.0004
75	1.086 ^a	1.086 ^a	1.083 ^b	1.085 ^{ab}	1.081 ^b	0.0004
78	1.086 ^a	1.084 ^b	1.086 ^{ab}	1.086 ^a	1.080 ^c	0.0004
82	1.083 ^a	1.083 ^a	1.082 ^a	1.083 ^a	1.077 ^b	0.0004
86	1.083 ^a	1.082 ^a	1.081 ^a	1.082 ^a	1.077 ^b	0.0004
90	1.082 ^a	1.080 ^{ab}	1.079 ^b	1.080 ^{ab}	1.078 ^b	0.0004
94	1.079 ^a	1.078 ^a	1.078 ^a	1.078 ^a	1.074 ^b	0.0004
99	1.080 ^a	1.078 ^a	1.078 ^{ab}	1.078 ^a	1.075 ^b	0.0005

^{a, b} Means within a row with no common superscripts are significantly different.

were also seen in the Haugh unit, egg shell thickness and egg specific gravity (Tables 4, 5 and 6, respectively). Compared with the values at 66 weeks (prior to fasting), the maximum improvement occurred at 78 weeks : the Haugh unit increased 5.4%, the egg shell thickness 5.7%, and the egg specific gravity 0.5%. Compared with the maximum value for the control group, the Haugh unit for the molted groups increased by a maximum 10.7 (86.1 : 75.4), the egg shell thickness by 0.038 (0.406 : 0.368) mm, the egg specific gravity by 0.006 (1.086 : 1.080). Neither CP level nor refeeding method affected these properties.

Discussion

ANDREWS *et al.* (1987) compared a 16% CP diet and a cracked corn diet, and BELL and KUNEY (1992) compared a 16.7% CP diet and a milo diet. Both reported that the difference in dietary CP did not affect performance and egg quality. Our findings here are similar : no difference between the 14.3% and 17.3% CP diets as a postmolt diet. This means that 14.3% CP content is adequate in a postmolt diet.

The mortality for the *ad libitum* feeding groups during the refeeding period was lower than that for the restricted feeding groups. In our experiments, the hens were housed in individual cages. If several hens had been housed in a single cage, the mortality due to fasting would have been even higher, because the stronger hens would have eaten all the food during the restricted feeding period, thus forcing the weaker hens to continue their fast.

In Japan, egg shell strength and Haugh unit, and not egg specific gravity, are usually used as a measure of egg quality. Recently, a standard value of egg strength and Haugh unit are used by large stores. Although Improvement in egg specific gravity was lowest among the properties measured in our study, the variance was the smallest. This means that egg specific gravity may be better than egg shell strength and Haugh unit as an index of egg quality.

Table 7. Coefficient of correlation by linear regression between egg weight (x) and egg strength (y) in forced-molted or non-molted layers

Age (weeks)	Forced-molted		Non-molted	
	Number	Coefficient	Number	Coefficient
66	116	0.05	30	-0.02
75	120	0.05	29	0.07
78	119	0.10	29	-0.14
80	120	0.06	30	-0.17
82	120	0.12	30	-0.06
84	119	-0.09	29	0.18
86	120	-0.06	29	0.02
88	119	-0.07	30	0.26
90	119	0.02	24	-0.26
92	120	-0.04	30	-0.02
94	120	-0.05	28	0.22
96	120	-0.18	27	0.05

It is commonly believed that big eggs generally have low egg shell strength, because bigger, eggs have thinner shells. We found however that the coefficient of correlation between egg weight and egg shell strength was very low for layers at the same age (Table 7). This indicates that egg weight does not affect egg shell strength and therefore controlling the egg weight is not effective in improving the egg shell strength.

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換羽後飼料の粗蛋白質レベルおよび再給餌方法の 産卵成績および卵質への影響

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飼料の粗蛋白質 (CP) レベルおよび再給餌方法の違いが強制換羽 (強換) 後の産卵成績および卵質に与える影響を 66 週齢の白レグ系産卵鶏 1,060 羽を用いて, 60 羽は強換せず対照区として調べた。

強換は点灯管理と絶食で実施し, 絶食は体重が 30% 減少するまで継続した。その後は 250 羽ずつの 4 区にわけ, ME 2.57 kcal/g-CP 14.3% と ME 2.85 kcal/g-CP 17.3% の飼料を自由摂取または 7 日間の制限給餌後自由摂取とした。換羽後飼料は産卵率が 5% に達するまで給与し, その後は ME 2.85 kcal/g-CP 17.3% の成鶏用飼料を給与した。

累積斃死率は, 再給餌を飽食させた方が少なかった。

卵重は高蛋白質飼料を再給餌した方が重い傾向にあった。しかし, 再給餌飼料や給餌方法の違いは, 産卵率, 日卵量, 摂取量, 卵質には影響を与えなかった。卵質は絶食開始後約 12 週間目に改善率が最大となり, その後漸減した。強換をしない区と比較すると, 卵殻強度, ハウ・ユニット, 卵殻厚および比重はそれぞれ最大で 1.23 kg/cm², 10.7, 0.038 mm, 0.006 優れていた。

以上の結果から換羽後飼料の CP は 14.3% 以下で, 再給与は飽食の方が良いことが示唆された。

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