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The Relationships among Egg Quality Characteristic of Different Hybrid Layers to Forced Molting Programs with and Without Feed Withdrawal

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Abstract: This research was carried out to determine the relationships among egg quality characteristics in post molt eggs of Brown layer (H and N Brown Nick) and White layer (Hy-Line W-36) with used non feed-withdrawal programs (BB: Barley Based, WB: Wheat Bran Based and OB: Oat Based) and Feed Withdrawal method (FW). Eggs for analyses were sampled from 76-93 weeks in second production. About 160 eggs were sampled for each week and it lasted 16 weeks. In total, 2,560 eggs were examined. There were significant ($p<0.01$) positive correlation between egg weight and albumen height and shell thickness and shape index. No significant correlation between specific gravity and albumen height and shape index were determined. There were significant ($p<0.01$) correlation between egg weight and specific gravity and albumen height for both genotypes (-0.384 and 0.110 in white layers, -0.329 and 0.169 in brown layers, respectively. There were no significant correlation between specific gravity and albumen height for both genotypes. There were significant ($p<0.01$) positive correlation between specific gravity and albumen height for BB and OB programs but no significant correlation between specific gravity and albumen height for FW and WB programs were found.

Key words: Correlation, egg quality characteristics, forced molting, feed-withdrawal, non-feed withdrawal, hybrid layer

INTRODUCTION

Induced molting of laying hens is a widely utilized management technique in the commercial egg industry. The main purpose of molting is to cease egg production in order to enter hens to a non reproductive state, which increase egg production and egg quality postmolt (Webster, 2003).

There are several molting methods. Feed to Withdrawal (FW) has been the most popular due easy of application, economic benefits and agreeable postmolt performance (Bell, 2003). However, recent concerns have been raised about animal welfare during the FW period because it is thought to be harmful to hens (Webster, 2003) and hens undergoing fasting appear to be more susceptible to *Salmonella enterica* serovar Enteritidis (*S. enteritidis*) colonization of the gastrointestinal tract and infections (Holt, 2003; Ricke, 2003) and weakening of the immune response (Holt, 1992).

Historically researchers have examined alternative molting programs to FW program (Sarica *et al*., 1996; Bell, 2003; Bar *et al*., 2003; Berry and Brake, 1985). Recently, the use of insoluble plant fibbers have been investigated and successful alternative molt induction diets have been developed from grape pomace, wheat middling, cottonseed meals, jojoba meal and alfalfa meal (Vermaut *et al*., 1997; Seo *et al*., 2001; Davis *et al*., 2002; Keshavarz and Quimby, 2002; Biggs *et al*., 2003, 2004; Landers *et al*., 2005; Donalson *et al*., 2005). Egg quality characteristics are influenced by many factors. The factors including genotype and age affect egg quality.

Genotype and age was those of the most important factors. The genotype affects mainly egg weight and egg shell characteristics. Several studies have shown heavier eggs in Brown hens than in white ones (Basmacioglu and Ergul, 2005; Karacay and Sarica, 2003; Vits *et al*., 2005; Zita *et al*., 2009). The age of hens is another of the factors influencing egg weight. Silversides and Budgell (2004), Akbas *et al*. (1996), Van den Brand *et al*. (2004) and Zita *et al*. (2009) showed that the egg weight increased with the hen's age. Zita *et al*. (2009) and Akbas *et al*. (1996) observed that hough unit was decreased with hen's age increasing.

The objective of the current study were to determine the relationships among egg quality characteristics in post molt eggs of two different laying hens with used non feed-withdrawal methods.

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MATERIALS AND METHODS

An experiment was conducted using 320 Hy-Line W-36 and 320 H and N Brown Nick hens (57 weeks of age). Hens were housed 4 per cage for the molting procedure.

The hens were divided into 8 treatment groups: FW (control); BB (70% barley and 27% alfalfa); WB (32% wheat bran, 44% corn and 21% alfalfa) and OB (70% oat and 27% alfalfa) for Hy-Line W-36 and H and N Brown Nick, each treatment having four replicate of 20 hens. The three diets were formulated to containing no salt, 1% Ca, 0.5% non-phytate P and 10% and more crude fiber using NRC (1994) table values.

Vitamin and amino acid (as percent of crude protein) contents of the experimental diets were supplied adequately considering the management guides of used hybrid genotypes.

All treatments were allowed adlibitum access to water and their respective diets. On day 1, the photoperiod was reduced to 10 h. On day 43, the daily photoperiod was increased 30 min week^{-1} for 12 weeks until a 16 h photoperiod was established. The experiment consists of a 6 weeks molt period followed by a 40 weeks post molt production period.

FW treatment, which was carried out with 8 days feed withdrawal was followed by feeding a resting diet (13% CP and 2500 Kcal kg^{-1} ME) for 32 days and three other treatments were provided adlibitum for 42 days with their own diets. On day 43, all hens were placed on a 15.5% CP layer diet (Table 1). Eggs for analyses were sampled from 76-93 weeks in second production. In each week, 160 eggs were sampled at a 16 weeks. In total, 2,560 eggs were examined.

The egg weight, specific gravity, albumen height, hough unit, shell thickness, percentage of eggshell, length of egg and breadth of egg were determined. Egg weight was measured using a balance and was recorded to the nearest 0.01 g.

Specific gravity was estimated by Archimedes method (Wells, 1968). All eggs were broken on to a flat surface, the height albumen was measured with a linear height gage and expressed in mm. Hough unit was calculated from records of egg weight and albumen height as an indicator of interior egg quality (Sarica and Erensayin, 2004).

Shell thickness was measured at three areas (broad end, middle portion and narrow end of the shell), by using a micrometer. Length of egg and breadth of egg were measured and the shape index was calculated (breadth of egg/length of egg×100). Correlations between egg quality characteristics were determined according to the procedure of Minitab (2000) by Pearson correlation coefficients.

Table 1: Composition of experimental molting diets, resting diet used after feed withdrawal and the layer diet used in post molt production period

Ingredients and analysis	Barley based (%)	Oat based (%)	Wheat bran based (%)	Resting diet (%)	Layer diet (%)
Corn, yellow (8.8%)	-	-	43.67	55.89	65.42
Alfalfa (13%)	26.97	27.47	21.16	-	-
Oat (11.4%)	-	70.00	-	-	-
Barley (11.6%)	70.00	-	-	-	-
Soybean meal (43%)	-	-	-	4.98	18.56
Sunflower seed meal (36%)	-	-	-	-	4.75
Wheat bran (15.7%)	-	-	32.15	35.47	-
Limestone	0.342	0.030	0.688	1.479	7.997
Dicalcium phosphate	2.198	2.152	1.829	1.742	1.924
Salt	-	-	-	-	0.176
Vit-Min. premix[1]	0.250	0.250	0.250	0.250	0.250
DL-Methionine, 98%	0.114	0.074	0.099	0.083	0.091
L-Lysine	0.126	0.024	0.154	0.106	-
Vegetable oil	-	-	-	-	0.832
Total	100	100	100	100	100
Calculated analysis[2]					
Crude protein (%)	11.8	12.2	11.84	13	15.5
Metabolizable energy (kcal kg^{-1})	2207	2133	2200	2500	2800
Crude fiber (%)	10.6	10.5	10	5.29	1.44
Calcium (%)	1	1	1	1	3.60
Available phosphorus (%)	0.5	0.5	0.5	0.5	0.45
Sodium (%)	0.062	0.071	0.052	0.160	0.188
Lysine (%)	0.531	0.550	0.533	0.585	0.733
Methionine + cystine (%)	0.449	0.464	0.449	0.490	0.603
Threonine (%)	0.438	0.412	0.415	0.461	-
Tryptophan (%)	0.156	0.191	0.179	0.189	0.194

[1]Provided per kilogram of diet; vitamin A, 12000 I.U; vitamin D_3, 2400 I.U; vitamin E, 25.0 mg; vitamin K_3, 4.0 mg; vitamin B_1 (thiamine), 3.0 mg; vitamin B_2 (riboflavin), 5.0 mg; vitamin B_6, 8.0 mg; vitamin B_{12}, 0.015 mg; niacin, 25.0 mg; calcium-D-pantothenate, 8.0 mg; D-Biotin, 0.05 mg; folic acid, 0.5 mg; choline choride, 125.0 mg; manganese, 80.0 mg; iron, 60.0 mg; zinc, 60.0 mg; copper, 5.0 mg; iodine, 1.0 mg; cobalt, 0.2 mg; Selenium, 0.15 mg, [2]Based on NRC (1994) feed composition tables

RESULTS AND DISCUSSION

Correlations between egg weight, specific gravity, albumen height, hough unit, shell thickness, egg length, egg breadth and shape index are shown in Table 2. The correlation coefficient of egg weight with shape index and shell thickness were positive (0.075 and 0.091, p<0.01) but that of specific gravity and eggshell percentage with egg weight were negative (-0.317 and -0.293, p<0.01). These results agree with the findings of Zita *et al*. (2009), who found positive correlation between egg weight and eggshell thickness of Brown hens in first production. Positive correlations between egg weight, shell weight and shell thickness has also been reported by Farooq *et al*. (2001). There were significant (p<0.01) negative correlation between egg weight and specific gravity (-0.317). Likewise, Durmus (2006) reported that the correlation coefficient (r = -0.118) between egg weight and egg specific gravity were determined White egg layer parents in first production. In this trial, shell percentage was strongly (p<0.01) correlated with shell thickness in white layers (r = 0.749). This finding was in partial agreement with a report Zita *et al*. (2009), who determined that positive (0.550) correlation between shell percentage and shell thickness in first production. While it was determined that there were significant (p<0.01) positive correlation between shell percentage and specific gravity, hough unit, shell thickness (0.394, 0.088 and 0.366, respectively), there were significant (p<0.01) negative correlation between shell percentage and egg weight (-0.293).

Highly significant (p<0.01) positive correlation between albumen height and hough unit, shape index (0.953 and 0.163, respectively) were determined. There were significant (p<0.01) negative correlation between hough unit and egg weight (-0.061) but there were significant (p<0.01) positive correlation between hough unit and specific gravity and albumen height (0.078 and 0.953). There were no correlation between specific gravity and albumen height and shape index. Correlation coefficient of egg percentage with egg weight were negative (-0.293, p<0.01) but that of specific gravity, hough unit and shell thickness with shell percentage were positive (0.394, 0.088 and 0.366, respectively). Significant (p<0.01) positive correlation between shape index and albumen height, Hough unit and shell thickness (0.163, 0.143 and 0.150, respectively) were found. While it was determined that there were no significant correlation

Table 2: Phenotypic correlations between external and internal egg quality characteristics in post molt production $(r_p \pm S\bar{X})$

Characteristics	EW	SG	AH	HU	ST	SP	EL	EB
SG	$-0.317\pm0.019^{**}$	-						
AH	$0.128\pm0.020^{**}$	0.004 ± 0.020^{NS}	-					
HU	$-0.061\pm0.020^{**}$	$0.078\pm0.020^{**}$	$0.953\pm0.006^{**}$	-				
ST	$0.091\pm0.020^{**}$	$0.062\pm0.020^{**}$	0.035 ± 0.020^{NS}	0.025 ± 0.020^{NS}	-			
SP	$-0.293\pm0.019^{**}$	$0.394\pm0.018^{**}$	0.032 ± 0.020^{NS}	$0.088\pm0.020^{**}$	$0.366\pm0.018^{**}$	-		
EL	$0.597\pm0.016^{**}$	-0.032 ± 0.020^{NS}	$-0.050\pm0.020^{*}$	$-0.156\pm0.020^{**}$	$-0.097\pm0.020^{**}$	$-0.093\pm0.020^{**}$	-	
EB	$0.701\pm0.014^{**}$	-0.031 ± 0.020^{NS}	$0.133\pm0.020^{**}$	0.005 ± 0.020^{NS}	$0.070\pm0.020^{**}$	$-0.071\pm0.020^{**}$	$0.389\pm0.018^{**}$	-
SI	$0.075\pm0.020^{**}$	0.002 ± 0.020^{NS}	$0.163\pm0.020^{**}$	$0.146\pm0.020^{**}$	$0.150\pm0.020^{**}$	0.023 ± 0.020^{NS}	$-0.577\pm0.016^{**}$	$0.525\pm0.017^{**}$

** = p<0.01; * = p<0.05; NS = Not Significant. EW = Egg Weight; SG = Specific Gravity; AH = Albumen Height; HU = Hough Unit; ST = Shell Thickness; SP = Shell Percentage; EL = Egg Length; EB = Egg Breadth; SI = Shape Index

Table 3: Phenotypic correlations between external and internal egg quality characteristics of white and brown layers in post molt production $(r_p \pm S\bar{X})$

Characteristics	EW	SG	AH	HU	ST	SP	EL	EB
WL								
SG	$-0.384\pm0.026^{**}$							
AH	$0.110\pm0.028^{**}$	-0.020 ± 0.028^{NS}						
HU	$-0.057\pm0.028^{*}$	$0.071\pm0.028^{*}$	$0.939\pm0.010^{**}$					
ST	-0.024 ± 0.028^{NS}	$0.066\pm0.028^{*}$	$0.069\pm0.028^{*}$	$0.067\pm0.028^{*}$				
SP	$-0.257\pm0.027^{**}$	0.032 ± 0.028^{NS}	$0.084\pm0.028^{**}$	$0.122\pm0.028^{**}$	$0.749\pm0.019^{**}$			
EL	$0.637\pm0.022^{**}$	-0.055 ± 0.028^{NS}	-0.029 ± 0.028^{NS}	$-0.118\pm0.028^{**}$	$-0.122\pm0.028^{**}$	$-0.232\pm0.027^{**}$		
EB	$0.682\pm0.021^{**}$	-0.055 ± 0.028^{NS}	$0.092\pm0.028^{**}$	-0.009 ± 0.028^{NS}	-0.050 ± 0.028^{NS}	$-0.259\pm0.027^{**}$	$0.402\pm0.026^{**}$	
SI	-0.035 ± 0.028^{NS}	0.005 ± 0.028^{NS}	$0.106\pm0.028^{**}$	$0.105\pm0.028^{**}$	$0.076\pm0.028^{**}$	0.006 ± 0.028^{NS}	$-0.626\pm0.022^{**}$	$0.461\pm0.025^{**}$
BL								
SG	$-0.329\pm0.026^{**}$							
AH	$0.169\pm0.028^{**}$	0.051 ± 0.028^{NS}						
HU	-0.028 ± 0.028^{NS}	$0.113\pm0.028^{**}$	$0.968\pm0.007^{**}$					
ST	$0.064\pm0.028^{*}$	$0.072\pm0.028^{*}$	0.038 ± 0.028^{NS}	0.043 ± 0.028^{NS}				
SP	$-0.378\pm0.026^{**}$	$0.945\pm0.009^{**}$	0.028 ± 0.028^{NS}	$0.106\pm0.028^{**}$	$0.283\pm0.027^{**}$			
EL	$0.555\pm0.023^{**}$	-0.004 ± 0.028^{NS}	-0.054 ± 0.028^{NS}	$-0.170\pm0.028^{**}$	$-0.148\pm0.028^{**}$	$-0.085\pm0.028^{**}$		
EB	$0.687\pm0.020^{**}$	-0.011 ± 0.028^{NS}	$0.186\pm0.028^{**}$	0.051 ± 0.028^{NS}	0.049 ± 0.028^{NS}	$-0.064\pm0.028^{*}$	$0.357\pm0.026^{**}$	
SI	$0.118\pm0.028^{**}$	-0.006 ± 0.028^{NS}	$0.211\pm0.027^{**}$	$0.194\pm0.027^{**}$	$0.170\pm0.028^{**}$	0.018 ± 0.028^{NS}	$-0.572\pm0.023^{***}$	$0.559\pm0.023^{**}$

** = p<0.01; * = p<0.05; NS = Not Significant. EW = Egg Weight; SG = Specific Gravity; AH = Albumen Height; HU = Hough Unit; ST = Shell Thickness; SP = Shell Percentage; EL = Egg Length; EB = Egg Breadth; SI = Shape Index; WL = White Layer (Hy-Line W-36); BL = Brown Layer (H and N Brown Nick) between egg weight and shell thickness and shape index in white layers, there were significant ($p<0.05$) positive correlation egg weight and shell thickness and shape index in brown layer (0.064, 0.118, respectively) (Table 3). No significant correlation between specific gravity and shell percentage in white layers but there were high significant ($p<0.01$) correlation between specific gravity and shell percentage (0.945) in brown layer were determined. There were no significant correlation between albumen height and shell thickness and shell percentage in brown layers but there were significant ($p<0.05$ and $p<0.01$, respectively) correlation between albumen height and shell thickness and shell percentage in white layer (0.069 and 0.084, respectively). This results in partial agreement with a report Wolanski *et al.* (2007), who found positive correlation (0.126) between albumen height and shell thickness in broiler breeder strains. It was found that no significant correlation between hough unit and shell thickness in Brown layer, but there were significant ($p<0.05$) correlation between hough unit and shell thickness in white layer (0.067). Correlations between egg weight, specific gravity, albumen height, hough unit, shell thickness, egg length, egg breadth and shape index in forced molt programs are presented in Table 4. There were no significant correlation between egg weight and specific gravity in oat based program, but there were significant ($p<0.01$) negative correlation between egg weight and specific gravity in BB, FW and WB programs (-0.112, -0.474 and -0.414, respectively). There were significant ($p<0.05$) negative correlation between egg weight and Hough unit in WB program (-0.087) but no significant correlation in other programs between egg weight and hough unit. While it was determined that there were significant ($p<0.01$) positive correlation between specific gravity and albumen height in BB and OB programs (0.110, 0.135, respectively), there were no significant correlation between specific gravity and albumen height in FW and WB programs. There were significant ($p<0.01$, $p<0.05$) correlation between specific gravity and hough unit in BB, FW, WB and OB programs (0.129, 0.082, 0.149

Table 4: Phenotypic correlations between external and internal egg quality characteristics of feed and non-feed withdrawal programs in post molt production ($r_p \pm S\bar{X}$)

Characteristics	EW	SG	AH	HU	ST	SP	EL	EB
BB								
SG	-0.112±0.039**							
AH	0.106±0.039**	0.110±0.039**						
HU	-0.074±0.039NS	0.129±0.039**	0.971±0.009**					
ST	0.101±0.039*	0.780±0.025**	0.058±0.040NS	0.043±0.040NS				
SP	-0.229±0.39**	0.812±0.023**	0.044±0.040NS	0.084±0.039*	0.769±0.025**			
EL	0.631±0.031**	-0.211±0.039**	-0.153±0.039**	-0.272±0.038**	-0.058±0.039NS	-0.258±0.038**		
EB	0.731±0.027**	-0.033±0.040NS	0.123±0.039**	-0.004±NS	0.144±0.039**	-0.146±0.039**	0.327±0.037**	
SI	0.144±0.039**	0.142±0.039**	0.233±0.039**	0.216±0.039**	0.175±0.038**	0.082±0.039*	-0.527±0.034**	0.629±0.031**
FW								
SG	-0.474±0.035**							
AH	0.113±0.039**	-0.030±0.039NS						
HU	-0.071±0.039NS	0.082±0.039*	0.923±0.015**					
ST	-0.009±0.039NS	0.057±0.039NS	-0.084±0.039*	-0.064±0.039NS				
SP	-0.235±0.038**	0.021±0.039NS	-0.055±0.039NS	0.008±0.039NS	0.793±0.024**			
EL	0.570±0.032**	-0.074±0.039NS	0.005±0.040NS	-0.081±0.039*	-0.168±0.039**	-0.253±0.038**		
EB	0.655±0.030**	-0.070±0.039NS	0.096±0.039*	-0.014±0.039NS	-0.068±0.039NS	-0.218±0.038**	0.396±0.036**	
SI	0.083±0.039*	0.004±0.039NS	0.081±0.039*	0.058±0.039NS	0.093±0.039*	0.032±0.039NS	-0.555±0.033**	0.542±0.033**
WB								
SG	-0.414±0.036**							
AH	0.105±0.039**	0.067±0.039NS						
HU	-0.087±0.039*	0.149±0.039**	0.965±0.010**					
ST	0.117±0.039**	0.031±0.039NS	0.062±0.039NS	0.058±0.039NS				
SP	-0.440±0.035**	0.978±0.008**	0.067±0.039NS	0.156±0.039**	0.177±0.039**			
EL	0.561±0.033**	0.036±0.039NS	-0.018±0.039NS	-0.120±0.039**	-0.098±0.039*	-0.014±0.039NS		
EB	0.682±0.029**	0.013±0.039NS	0.102±0.039*	-0.024±0.039NS	0.085±0.039*	-0.023±0.039NS	0.463±0.035**	
SI	0.059±0.039NS	-0.024±0.039NS	0.111±0.039**	0.098±0.039*	0.172±0.039**	-0.007±0.039NS	-0.588±0.032**	0.441±0.035**
OB								
SG	-0.023±0.039NS							
AH	0.194±0.038**	0.135±0.039**						
HU	-0.005±0.039NS	0.146±0.039**	0.971±0.009**					
ST	0.167±0.039**	0.526±0.034**	0.109±0.039**	0.079±0.039*				
SP	-0.137±0.039**	0.496±0.034**	0.026±0.039NS	0.059±0.039NS	0.727±0.027**			
EL	0.642±0.030**	-0.103±0.039*	-0.041±0.039NS	-0.174±0.039**	-0.065±0.039NS	-0.193±0.039**		
EB	0.759±0.026**	0.007±0.039NS	0.235±0.038**	0.087±0.039*	0.121±0.039**	-0.111±0.039**	0.370±0.037**	
SI	-0.007±0.039NS	0.103±0.039*	0.2310.038**	0.239±0.038**	0.158±0.039**	0.097±0.039*	-0.660±0.029**	0.452±0.035**

** = $p<0.01$; * = $p<0.05$; NS = Not Significant. BB = Barley Based; FW = Feed Withdrawal; WB = Wheat Bran Based; OB = Oat Based; EW = Egg Weight; SG = Specific Gravity; AH = Albumen Height; HU = Hough Unit; ST = Shell Thickness; SP = Shell Percentage; EL = Egg Length; EB = Egg Breadth; SI = Shape Index; WL = White Layer; BL = Brown Layer and 0.146, respectively). Significant positive correlation between shell thickness and shape index in BB, FW, WB and OB programs were founded (0.175, 0.093, 0.172, 0.158 and $p<0.01$, $p<0.05$, $p<0.01$ and $p<0.01$, respectively).

CONCLUSION

In this study, we obtained correlation among egg quality characteristics in different genotypes and different forced molting programs. According to the best knowledge, we did not find any study about relationship among egg quality characteristics in second production that used forced molting. Different values were observed in some quality characteristics both genotype and forced molting programs. These differences may be due to genotype affect some egg quality characteristics.

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