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# MULTIPLE REGRESSION ANALYSIS OF EGGSHELL MEASUREMENTS IN TWO GENETIC GROUPS OF CHICKEN

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## ABSTRACT

The research was conducted on eggs of 148 heterozygous naked neck (Nana) and 124 normally feathered (nana) genotype chickens maintained in individually cages. Three hundred eggs selected randomly (150 each). Egg weights (g), egg length (mm), egg width (mm), eggshell weight (g), eggshell thickness (mm) and deformation were measured. The present results revealed that birds having Na inheritance had superior eggshell quality compared to nana genotype. Shape index was negatively correlated with eggshell deformation in both genotypes. However, there was significantly negative relationship between shape index and shell thickness in nana genotype. The eggshell percentage was significantly positive correlated with shape index in Nana genotype. Opposite trend was noticed in nana ones. Eggshell deformation was significantly negative correlated with shell thickness, shell percentage and weight 1 Cm$^2$ shell in both genetic groups. The following equations were developed to predict shell thickness:

Y= 0.225EW-0.109SI+4.43SP-150WCM+3.29 ($R^2$=0.63) (Nana genotype),

Y= 0.072EW-0.076SI+1.373SP+245WCM+7.84 ($R^2$=0.78) (nana genotype).

Where, EW = egg weight, SI= shape index, SP = shell percentage and WCM = weight of 1cm$^2$ shell.

In conclusion, it can be concluded that incorporation of Na gene in laying hens improve eggshell quality. Also, prediction equations can be developed to get information about eggshell traits.

**Keywords:** Eggshell, naked neck gene, regression analysis

## INTRODUCTION

The eggshell is the natural packing material for the egg contents, and as a result, it is important to obtain high shell strength, to resist all impacts an egg is subjected to during the production chain (Bain, 1990). Broken eggs cause economic damage in 2 ways: they cannot be sold as first-quality eggs, and the occurrence of hair cracks raises the risk for bacterial contamination of the broken egg and of other eggs when leaking, creating problems with internal and external quality and food safety. The function of the eggshell is to protect the contents of the egg from mechanical impacts and micro-bacterial invasions (for example, Salmonella) and to control the exchange of water and gases through the pores during the extra-uterine development of the chick embryo (Fink *et al*., 1992; Nys *et al*., 1999). In the food market, the eggshell functions as a packaging material and its good quality is crucial to consumer selection and safety. So, great care is needed to preserve it intact. That is why the mechanical properties of the eggshell, and, in particular, the strength of the eggshell have been the subject of extensive research; its determination is helpful in predicting and preventing breakage of eggshells in the field (Tullet, 1987). Defects in shell quality cause significant losses to the commercial egg industry. Washburn (1982) and Hamilton (1982) estimated from several sources that between 6 and 7% of all eggs laid are downgraded or lost due to shell cracks or breakage. Such problems generally result from formation of a weak eggshell, rough handling of the egg after it is laid, or a combination of both. Occasionally products hypothesized to improve eggshell quality are introduced to the market (Lalshaw and Turner 1991). In some researchers, the egg weight is said to have a direct relation with the eggshell quality which has a positive correlations with the shell thickness (Choi *et al.,* 1983; Stadelman, 1986) and shell weight (Choi *et al*., 1983; Poyraz, 1989). It is also mentioned by some other researchers that the shell thickness has an effect on the shell stiffness (Bus, 1982; Thompson *et al.,* 1981). The research was carried out to evaluate the eggshell quality in two genetic groups of chicken, and predicting eggshell thickness and eggshell deformation using various egg traits as independent variables.

## MATERIALS AND METHODS

**Genetic groups and husbandry**

The present study was conducted at Poultry Breeding Farm, Poultry Production Department, Faculty of Agriculture, Ain Shams University. Normally feathered (nana) females were artificially inseminated with naked neck (Nana) males. According to the previous mating, tow genetic groups of females were obtained; normally feathered (nana) and heterozygous naked neck (Nana). All chicks were wing-banded and brooded in electrical brooding batteries from hatching to 4 weeks of age. Then, they were transferred to floor pen. All genetic groups were reared under similar environmental, managerial and hygienic conditions. Feed and water were supplied *ad libitum*. They were fed a diet containing 18% CP and 2900 kcal ME/kg diet.

**Measurements and observations**

At 40 weeks of age, tow eggs per hen were used from 148 heterozygous naked neck (Nana) and 124 normally feathered (nana) genotype of chicken. The egg length (long axis) and width (short axis) were measured with the electronic caliper. The width to length ratio was shown in percentage points and constituted the egg shape index. The eggshell, after the removal of the egg content, was dried. Subsequently the eggshell was weighed (g) at the nearest 0.01g. Eggshell thickness was measured (mm) with the micrometer. The eggshell by percentage was compared with the weight of a fresh egg.

**Statistical analysis**

Data were subjected to a one-way analysis of variance with strain effect using the General Linear Models (GLM) procedure of SAS User's Guide, 2001. Correlation coefficients among the different traits for each genotype were calculated using PROC CORR procedure. Stepwise regression analysis was used to determine and verify factors affecting eggshell traits within each genotype.

Yij = a + b1X1 + b2X2 + b3X3 + b4X4 + eij

Where;

Yij = the dependent variable of the ith bird;
a = intercept,
X1………..X4 = the pth independent variable of the ith bird,
b1…….b4 = regression coefficients of Y on Xs,
eij = experimental error.

## RESULTS AND DISCUSSION

**Eggshell traits**

Eggshell traits as affected by naked neck gene are summarized in Table (1). The present results revealed that there was no significant difference between genotype for egg weight, shape index and egg deformation. However, the presence of naked neck gene significantly increased shell thickness, shell percentage and weight 1 cm2 shell by about 1.7, 11.5 and 1.8%, respectively compared to nana genotype. Haque *et al.* (2001) reported that birds having Na inheritance had superior egg quality and thus it can be concluded that incorporation of Na gene to exotic breeds might improve egg quality of chicken. Juárez et al (2007) found that the dietary calcium retention was superior in the naked neck hens, due to, probably; they are more resistant to the respiratory alkalosis and maintain higher levels of blood bicarbonate than the normally feathered hens.

**Table 1: Eggshell traits of naked neck and normally feathered genotype chickens**

| Trait | Genotype | | Pooled SEM | Prob. | Gene effect |
|---|---|---|---|---|---|
| | Nana | nana | | | |
| **Egg weight, g** | 57.63 | 57.12 | 2.06 | NS | +0.89 |
| **Shape index, %** | 74.91 | 74.84 | 2.69 | NS | +0.09 |
| **Deformation** | 20.90 | 20.99 | 2.46 | NS | -0.43 |
| **Shell thickness, 1/100mm** | 36.56 | 35.98 | 2.90 | 0.05 | +1.70 |
| **Shell, %** | 8.93 | 8.80 | 0.73 | 0.01 | +11.53 |
| **Weight 1 Cm$^2$ shell (1/100g)** | 73.47 | 72.16 | 3.63 | 0.03 | +1.82 |

**NS = non-significant**
**Gene effect = (Nana-nana)/nana*100**

**Phenotypic correlation coefficients:** Phenotypic correlation coefficients of eggshell traits for Nana and nana genotypes are presented in Table (2). Negative relationship between egg weight and shape index was noticed in both genotypes, with statistically significant in nana genotype. Similar relationships were observed between egg weight and deformation. Eggshell thickness was positively correlated with egg weight in all genetic groups. Inversely, the eggshell percentage was negatively correlated with egg weight. In some other researchers, the egg weight is said to have a direct relation with the eggshell quality which has a positive correlations with the shell thickness (Choi *et al.,* 1983; Stadelman, 1986) and shell weight (Choi *et al.,* 1983; Poyraz, 1989). With respect to egg shape index, it could be observed that the shape index was negatively correlated with eggshell deformation in both genotypes. However, there was significantly negative relationship between shape index and shell thickness in nana genotype. The eggshell percentage was significantly positive correlated with shape index in Nana genotype. Opposite trend was noticed in nana ones. The weight of 1 $cm^2$ of shell was significantly negative relationship with shape index in nana genotype.

Eggshell deformation was significantly negative correlated with shell thickness, shell percentage and weight of 1 $cm^2$ shell in both genetic groups. There were significantly positive relationships between shell thickness and shell percentage in both genotypes. Similar result was noticed between shell percentage and weight of 1 $cm^2$ shell. Alkan *et al.* (2008) reported that the eggshell weight was found significantly ($P<0.01$) and positively associated with egg length and egg weight providing a good ground for predicting eggshell weight. But, the egg width has no significant effect on the eggshell weight. Khurshid *et al.* (2003) reported significant and positive association of eggshell weight with egg length and width of Japanese quails and regression coefficient was calculated as 7.01%.

**Table 2: Phenotypic correlation coefficients of eggshell measurements within genetic groups**

| Trait | Egg weight | Shape index | Deformation | Shell thickness | Shell (%) | Genotype |
|---|---|---|---|---|---|---|
| **Shape index** | -0.120 | | | | | Nana |
| | -0.213* | | | | | nana |
| **Deformation** | -0.121 | -0.163* | | | | Nana |
| | -0.028 | -0.047 | | | | nana |
| **Shell thickness** | 0.146 | 0.007 | -0.464** | | | Nana |
| | 0.138 | -0.281* | -0.483** | | | nana |
| **Shell, %** | -0.202* | 0.183* | -0.538** | 0.729*** | | Nana |
| | -0.141 | -0.180* | -0.518* | 0.843*** | | nana |
| **Wt. of 1 cm2 shell** | 0.139 | 0.127 | -0.580** | 0.739** | 0.908*** | Nana |
| | 0.141 | -0.250* | -0.541** | 0.884*** | 0.956*** | nana |

***P < 0.05 ** P< 0.01 *** P < 0.001**

## Predicting of eggshell thickness

The eggshell weight, shell thickness and eggshell stiffness are important egg traits that can't be exactly predetermined until and unless eggs are broken. However, prediction equations can be developed to get information about these traits without breaking eggs. Our results showed that the eggshell thickness of naked neck (Nana) genotype was predictable with accuracy ($P<0.01$) from egg weight and shell percentage (Table 3 & 4). The shape index and weight 1$Cm^2$ shell have no significant effects on the eggshell thickness. In this study, adjusted $R^2$ of the fitted model was 0.63. Following equation was developed for predicting eggshell thickness; Y = 3.29 + 0.225EW – 0.109SI + 4.43 SP – 150 $wcm^2$, Where; Y = will be predicted eggshell thickness, EW = egg weight, SI = shape index, SP = shell percentage and WCM2 = weight 1 $Cm^2$ shell. With respect to normally feathered (nana) genotype, the present results indicated that the eggshell thickness was predictable with accuracy from egg weight, shape index and shell percentage ($R^2$ = 0.78). However, the weight 1 $Cm^2$ shell did not effect on shell thickness. Following equation was developed for predicting eggshell thickness; Y = 7.84 + 0.072EW – 0.076SI + 1.37SP+245 wcm$^2$. Egg weight was easily predictable from egg length and width as positive association among these traits existed (Farooq *et al.,* 2001). Information on egg weight along with egg width and length will further open the domain for trying out various prediction equations in order to predict eggshell weight and shell thickness (Khurshid *et al.,* 2003). Positive correlations between egg weight, shell weight and shell thickness has also been reported by Farooq *et al.* (2001). This provides an indication for better prediction of eggshell weight and thickness from egg weight, width and length. While determining the qualities such as shell thickness, shell weight and the shell stiffness, either the compulsory of breaking of the egg or the need for the construction of some special mechanisms should be considered.

**Table 3: Coefficients of regression and constant for shell thickness trait**

| Genotype | Constant | EW | SI | SP | W.CM | $R^2$ |
|---|---|---|---|---|---|---|
| **Nana** | 3.29 | 0.225 | -0.109 | 4.43 | -150 | 0.63 |
| **nana** | 7.84 | 0.072 | -0.076 | 1.37 | 245 | 0.78 |

**EW: egg weight (g) SI: shape index (%) Sp: shell percentage W.cm$^2$: weight 1 Cm$^2$ shell**

**Table 4: Regression analysis for shell thickness trait of naked neck (Nana) and normally feathered (nana) genotype**

| | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Nana | | | nana | | |
| **S.O.V.** | df | MS | F. value | df | MS | F. value |
| **Regression** | 4 | 193.35 | 63.39** | 4 | 230.56 | 109.27** |
| **Egg weight** | 1 | 25.92 | 8.49** | 1 | 22.44 | 10.63** |
| **Shape index** | 1 | 0.72 | 0.23 | 1 | 77.70 | 36.82** |
| **Shell (%)** | 1 | 737.71 | 241.87** | 1 | 819.58 | 388.42** |
| **Wt. 1cm$^2$ shell** | 1 | 9.06 | 2.97 | 1 | 2.52 | 1.19 |
| **Residual** | 143 | 3.05 | | 119 | 2.11 | |

**Predicting eggshell deformation**

In accordance to naked neck genotype, the present results in Tables (5 & 6) indicated that the eggshell deformation was predictable with enough accuracy (P<0.01) from shape index, shell thickness and shell percentage. Following equation was developed to predict eggshell deformation: Y = 75.6 - 0.146EW – 0.162SI – 0.071STH – 2.05SP – 180 W.cm2. With respect to nana genotype, it could be noticed that the eggshell deformation was predictable from shell thickness, shell percentage and weight 1 Cm$^2$ shell.

**Table 5: Coefficients of regression and constant for eggshell deformation**

| Genotype | Constant | EW | SI | STH | SP | W.CM | $R^2$ |
|---|---|---|---|---|---|---|---|
| **Nana** | 75.6 | -0.146 | -0.162 | -0.071 | -2.05 | -180 | 0.33 |
| **nana** | 44.4 | 0.527 | -0.331 | -0.136 | 9.99 | -1551 | 0.33 |

**EW: egg weight (g) SI: shape index (%) STH: shell thickness**
**Sp: shell percentage W.CM: weight 1 Cm$^2$ shell**

**Table 6: Regression analysis for eggshell deformation trait of naked neck (Nana) and normally feathered (nana) genotypes**

| | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Nana | | | nana | | |
| **S.O.V.** | **df** | **MS** | **F. value** | **df** | **MS** | **F. value** |
| **Regression** | 5 | 249.99 | 15.71** | 5 | 152.95 | 13.25** |
| **Egg weight** | 1 | 51.31 | 3.22 | 1 | 1.63 | 0.14 |
| **Shape index** | 1 | 112.55 | 7.07** | 1 | 6.32 | 0.54 |
| **Shell thickness** | 1 | 700.83 | 44.04** | 1 | 564.97 | 48.95** |
| **Shell (%)** | 1 | 372.55 | 23.41** | 1 | 128.49 | 11.13** |
| **Wt. 1cm$^2$ shell** | 1 | 12.71 | 0.79 | 1 | 63.35 | 5.48* |
| **Residual** | 142 | 15.91 | | 118 | 11.54 | |

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## تحليل الانحدار المتعدد لمقاييس قشرة البيضة فى مجموعتين وراثيتين من الدجاج

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أجريت هذه التجربة على بيض متحصل علية من دجاجات عارية الرقبة خليطة وأخرى طبيعية الترييش. استخدم فى هذه الدراسة عدد ٣٠٠ بيضة (١٥٠ بيضة من كل تركيب). تم قياس وزن البيضة، الوزن النسبي للقشرة، سمك القشرة، دليل البيضة، بالإضافة إلى تشوه قشرة البيضة. أوضحت النتائج المتحصل عليها أن الطيور عارية الرقبة الخليطة أنتجت بيض ذات جودة قشرة أعلى من البيض الناتج من طيور طبيعية الترييش. وجد ارتباط سالب بين دليل البيضة وتشوه البيضة فى كلا التركيبين الوراثيين. بينما وجد ارتباط سالب بين دليل البيضة وسمك القشرة فى التركيب طبيعي الترييش. وجد ارتباط معنوي موجب بين دليل البيضة والوزن النسبى لقشرة البيضة فى التركيب الوراثي عاري الرقبة، بينما شوهد عكس الاتجاه فى التركيب الوراثي طبيعي الترييش. شوهد ارتباط معنوي سالب بين تشوه القشرة وكل من سمك القشرة ونسبة القشرة ووزن ١ سم٢ من القشرة فى كل المجاميع الوراثية. تم التحصل على معادلات انحدار للتوقع بسمك القشرة:

Y= 0.225EW-0.109SI+4.43SP-150WCM+3.29 ($R^2$=0.63) (عاري الرقبة),

Y= 0.072EW-0.076SI+1.373SP+245WCM+7.84 ($R^2$=0.78) (طبيعي الترييش).

**الخلاصة**، من الممكن إدخال العامل الوراثي عرى الرقبة فى الدجاجات البياضة لتحسن جودة قشرة البيض. بالإضافة إلى امكانية التوقع بجودة قشرة البيض.