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PREDICTION OF FEED INTAKE AND RESIDUAL FEED CONSUMPION IN LAYING HEN CHICKENS

By

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Abstract: *An experiment was conducted to determine the expected feed consumption (EFC) and residual feed consumption (RFC) in brown and white Hy-line strains. Two hundred and ten Hy-line hens (120 white and 90 brown) were used. The experiment began when the hens aged 20 wk of age and lasted at 24 wk. All hens were kept under similar environmental, managerial and hygienic conditions. Main results obtained could summarized as follows:*

- *The brown Hy-line hens had significantly heavier body weight compared to white Hy-line ones.*
- *The brown hens were significantly heavier than that of the white ones.*
- *Egg production rate for white Hy-line hens was higher than that of brown Hy-line ones.*
- *The brown Hy-line hens significantly consumed more feed compared to white ones. However, the white Hy-line hens had a better feed conversion ratio compared to brown Hy-line hens.*
- *The regression equation calculated for white Hy-line hens had a better rate of determination (R^2) compared to brown Hy-line ones.*
- *The observed feed consumption values were somewhat closely to expected feed consumption values in white Hy-line hens compared to brown Hy-line hens.*
- *Highly significant positive correlation between RFC and body weight was observed in both brown and white Hy-line strains.*
- *Egg mass and egg number were negatively correlated with RFC in both brown and white Hy-line strains.*
- *Plasma globulin was highly significant positively correlated with RFC in white Hy-line strain. Similar trend, but very low, was observed in brown Hy-line one.*
- *There was an inverse significant relationship between plasma albumen and RFC for white Hy-line strain.*

- *Yolk percentage was significantly positive correlated with RFC in white Hy-line strain. Similar relationship, but not statistically significant, was observed in brown Hy-line one.*
- *Shell thickness was significantly positive correlated with RFC in white Hy-line strain, however, this correlation was low in brown Hy-line one.*
- *In conclusion, the results of the present study suggest that more consideration should be given to the difference among various genetic stocks in their requirements for maintenance and egg production. The results also suggest the possible use of the partial regression coefficient as selection criteria for improving feed efficiency for maintenance and egg production.*

INTRODUCTION

Feed expenses are the main cost in egg production. Therefore, efficient layers are important for the economy of the farm. Traditionally, efficiency has been improved by selection on egg mass production and body weight and getting a correlated response in feed efficiency (Luiting, 1990). Recently, the uses of feed consumption data or parameters estimates including feed consumption in the selection have been suggested to be good tools for improving feed efficiency. Under standardized environment, differences in production, body weight and weight gain explains only 80-90% of the variation in efficiency between strains of laying hens and 70-90% of the variation between individuals within strains (Bentsen, 1980). The unexplained variation in feed consumption (residual feed consumption) can be though of as a variation in deviation between observed feed consumption and expected feed consumption, which estimated from a multiple regression with feed consumption as the dependent variable and egg mass, metabolic body weight ($BW=BW^{0.75}$) and weight gain as independent variables. Several authors have tried to derive the energy requirements of laying hens and have proposed different production equations (Leeson *et al.,* 1973; Hurnik *et al.,* 1977; Balnave *et al.,* 1978; McDonald, 1978; Damme, 1993; Brenoe, 1996). Also, Bentsen (1987) concluded that genetic improvement of feed efficiency in laying hens has been realized mainly as a correlated response to selection for higher egg production level and through deliberate reduction of maintenance requirements by selection for a low adult body weight. Nevertheless, attention is shifting to direct selection for feed efficiency, because the rate of progress in feed efficiency is decreasing.

The breeding goal for commercial layers is maximum egg income over feed cost, not minimum RFC (Flock, 1998). Selection can be practiced directly on egg mass (maximum egg number, holding egg weight at a desirable level) and feed consumption, using appropriate economic weight.

In commercial breeding program, feed consumption or RFC has to be integrated in a complex breeding value estimation procedure, this uses information on different traits, collected at different times, from different relatives and perhaps several generations (Flock, 1998). As pointed out by Kennedy *et al.* (1993), multiple trait selection on production and RFC, based on either phenotypic or genetic regression, is equivalent to multiple trait selection on production and feed consumption. Because the partial regression

Coefficients of feed consumption on body weight and egg mass differ between lines, time and duration of measurements. The present experiment was designed to predicate feed intake and residual feed consumption in brown and white Hy-line strains under Egyptian conditions. This information would be useful in selection of commercial layers to improve efficiency of feed utilization.

MATERIALS AND METHODS

This experiment was conducted at Poultry Breeding Farm, Poultry Production Department, Faculty of Agriculture Ain Shams University. A total number of 120 White Hy-line and 90 Brown Hy-line were used. At 16 weeks of age, the birds were housed in individual cages suitable for the quantitative measurements of egg production and feed intake. All birds were kept under similar environmental, managerial and hygienic conditions, given 16h light/24h. The birds were provided *ad libitum* access to a commercial egg layer diet containing 18 crude protein and 2900 kcal ME/ kg.

Measurements and observations

Body weights were determined at 20 and 24 weeks of age. Egg production was recorded daily from the onset of lay until 24 weeks of age. The hens were individually weighed at the beginning of the feed consumptions experiment (20 weeks of age) and thereafter, they were reweighed on 24 weeks. Change in body weight was calculated by subtracting beginning weight from ending weight. Total egg mass produced in grams in that period, along with total feed consumption at this time were obtained. Feed wastage was carefully controlled to be very small.

Blood parameters

At 24 weeks of age, blood samples were taken from the brachial vein into heparinzed tubes for all birds. Plasma was obtained from the blood samples by centrifugation for 10 min. at 4000 rpm and was stored at -20C until the time of analysis. The frozen plasma was allowed to thaw prior to analysis. Plasma calcium, phosphorus, total protein and albumen were determined by enzymatic colorimetric methods using available commercial kits SCLAVO INC., 5 Mansard Count, Wayne NJ 07470, USA.

Egg quality assessment

Measurement at 24 weeks of age, an egg quality experiment was applied for each strain. Eggs were collected and weighed to the nearest 0.1 g. Egg shape was determined using the digital caliper to measure egg width and length. After measuring of internal egg quality, the liquid contents of the egg were a side and shell plus membranes washed to remove adhering albumen. Then, shells were weighed upon cooling to the nearest 0.01 g. Egg thickness in mm was measured using a digital micrometer.

Computing data and statistical analysis

The feed consumption for hens was predicted to derive regression equation according to strain. Residual feed consumption (RFC) was calculated as the difference between observed feed consumption (OFC) and expected feed consumption (EFC) for each experimental hen. Each strain had its own regression coefficients according to the following equation:

$$EFC = aBW_i^{0.75} + bEM_i + c\Delta W_i + d$$

Where: EFC = expected feed consumption of hen I (grams);

$BW_i^{0.75}$= mean metabolic body weight of hen I ($kg^{0.75}$)

EM_i = egg mass production of hen I (grams)

A, b and c = partial regression coefficients;

d = intercept.

All calculations and analyses were made using General Linear Models (GLM) procedure of SAS User's Guide, 2001. Correlation coefficients of RFC with productive traits were estimated for each strain using the PROC CORR procedure of SAS.

RESULTS AND DISCUSSION

Phenotypic parameters

Body weights, egg production, feed consumption and feed conversion ratio of brown and white Hy-line strains are listed in Table 1. The brown Hy-line hens were significantly ($p \leq 0.01$) heavier body weight compared to white Hy-line one. The brown hens produced heavier egg mass compared to white hens, but the difference was not statistically significant.

There was no significant difference between strains for egg number. The egg weight of brown hens was significantly heavier than that of white ones. The egg production rate of white hens was higher than that of brown ones, but the difference did not statistically significant. Both cracked and double eggs was not significantly affect by strain.

The brown hens were significantly consumed more feed compared to white ones. This result could be attributed to the heavier body and egg weight associated with brown hens compared to white hens. The white hens had a better feed conversion ratio compared to brown ones, but the difference was not statistically significant. Inversely, Hagger (1977 & 1978) reported that the feed conversion ratio in the high egg weight and body weight line was 12-15% superior to that of the low egg weight and low body weight line.

Internal egg quality of brown and white Hy-line strains at 24 weeks of age are summarized in Table 2. The brown hens significantly produced heavier egg weight compared to white hens by about 4.4 g. With respect to albumen weight percentage, it could be noticed that the albumen weight percentage of brown eggs was significantly higher than that of White strain. Inversely, the relative weight of yolk for brown eggs was lower than that of White eggs, but the difference was not statistically significant. The brown eggs were significantly higher albumen height compared to white eggs. There was no significant difference between strains for both yolk diameter and yolk height.

With respect to eggshell quality, data summarized in Table 3 shows that the shell weight of brown eggs was significantly heavier than white eggs. However, there was no significant difference between strains for shell weight percentage. Both short and long axial of brown eggs were significantly higher than that of white eggs. Moreover, the shape index of brown eggs was significantly higher than white eggs. The shell thickness of eggs did not significantly affect by strain.

Data presented in Table 4 shows there were no significant differences between brown and white Hy-line strains for total plasma protein, albumen, globulin, calcium and phosphorus.

Multiple regression equation of feed consumption

Observed feed consumption, egg mass, change in body weight and metabolic body weight for each hen within each strain were used to estimate the regression coefficients are listed in Table 5. The results revealed that the equation calculated for white Hy-line hens had a better rate of determination

(R^2 = 0.56) compared to brown Hy-line hens (R^2 = 0.44). That is mean, the figures of RFC calculated from these equations are more reliable and have a highly applicable prospective. Flock (1998) reported that the white egg layer has become relatively more efficient in terms of residual feed consumption, whereas these two stocks were reduced from 12 g to 6 g residual feed consumption. The present results appears that the regression of body weight on feed intake may differ between laying stock, but the accuracy of feed intake predictions is independent of the power used to express metabolic body weight. Pirchner (1985) reported that differences in observed feed consumption (OFC) and expected feed consumption are caused by variability in several factors, such as composition of product (eggs), body weight change, food spillage, metabolic rate and in the ability to synthesis egg and body constituents. Figure 1 illustrates the residual feed consumption values for each hen. While figure 2 depicts the observed against expected feed consumption for each hen within each strain. It was generally noticed that the observed values were somewhat closely to expected values for white Hy-line hens compared to brown Hy-line hens. This adjacency was reflected on RFC, where it was more consistent to zero line. Bearing in mined that the negative values of RFC are desirable rather than positive ones. The efficient hens which had negative RFC figures were more frequent than inefficient ones for white Hy-line hens to brown Hy-line hens. The results of Morrison and Leeson (1978); El-Sayed and El-Hakim (1994); Hussen *et al.* (2000) and Fathi *et al.* (2000) confirmed that the efficient birds were less actives, less heat production, spent more time resting and less time standing than inefficient bird . Also, Flock (1998) concluded that measurements or subjective scoring of correlated traits such as head appendage size, body temperature or activity may produce useful additional data for basic information needed to calculated RFC.

Correlations between RFC and quantitative traits

Calculation RFC by phenotypic multiple regression analysis is an acceptable alternative in a breeding program of no reliable estimates of genetic correlation are available (Luiting and Urff, 1991). This suggestion was reported because the author found the estimates of genetic correlation of RFC with the economic traits did not clearly differ from zero. Also, Tixier-Boichord *et al.* (1995) found that the genetic correlation between RFC and the independent variables used in the prediction equation (metabolic body weight, change in body weight and egg mass) were generally low, which confirms the validity of the selection on a phenotypic assessment of RFC. Data presented in Table 6 shows the correlations coefficients for some quantitative traits with residual feed consumption

(RFC), Highly significant positive correlations between RFC and body weight were observed in both brown and white Hy-line strains. Egg mass was negatively correlated with RFC in brown and white Hy-line strains. Similar correlations were noticed between egg number and RFC in both strains. Conversely, Tixier-Boichard *et al.* (1995) indicated that positive correlation between RFC and egg number. This conflicting may be due to the time of measurements, age of birds and location. Broken eggs percentage was positively correlated with RFC in brown Hy-line strain. However, this correlation was low and inverse in white Hy-line strain. The relationships between double yolked eggs percentage and RFC were positive and low in both strains. Highly positive correlations between RFC and observed feed consumption were noticed for both white and brown Hy-line strains. Similar trend, but not statistically significant, was observed for expected feed consumption.

With respect to blood parameters, it could be noticed the correlation between plasma total protein and RFC was low and inverse (rp = -0.12) in brown Hy-line strain. Inversely, this correlation was moderate and positive in white Hy-line strain.

There was a significant inverse relationship between plasma albumen and RFC in white Hy-line strain, however this relationship was low in brown Hy-line one. Plasma globulin was highly significant positive correlated with RFC in white Hy-line strain. Similar trend, but very low was observed in brown Hy-line one. Significant positive correlation between plasma calcium and RFC was noticed in white Hy-line hens, however this correlation did not statistically significant and low in brown Hy-line strain. There was inverse an relationship between plasma phosphorus and RFC were observed in brown and white Hy-line strains.

Concerning internal and eggshell quality traits, it could be observed that there was significant positive relationship between albumen percentage and RFC in white Hy-line strain. However, this correlation was low in white Hy-line one. Some of the differences in RFC between hens may be due to variable yolk (or dry matter) content of eggs. The yolk percentage was significantly positive correlated with RFC (rp = 0.49) in white Hy-line strain. Similar trend (rp = 0.33), but not statistically significant, was observed in brown Hy-line one. El-Sayed and El-Hakim (1994) calculated significant and high positive association between RFC and the yolk percent in full-sib normal and dwarf hens. The author showed that the positive correlation probably reflects the increase in dry matter percentage and energy content in the egg when the proportion of yolk increases. Also, Heil (1976) and Bentsen (1980) found positive correlations between the percentage yolk and feed consumption rate. The relationship between shell percentage and RFC was low and positive for both brown and white Hy-line strains. The shell thickness was significantly positive correlated (rp = 0.47) with RFC in white Hy-line strain, but this correlation was low (rp = 11) in brown Hy-line strain.

Bordas and Mérat (1981) reported that account only of variable showing highly significant correlations with RFC among females (Wattle length, shank length, broken eggs, yolk: albumen ratio), the proportion of the total variance in RFC which is explained by these correlations is about 20%.

In conclusion, the results of the present study suggest that more consideration should be given to the difference among various genetic stocks in their requirements for maintenance and egg production. The results also suggest the possible use of the partial regression coefficient as selection criteria for improving feed efficiency for maintenance and egg production.

Table 1. Body weights and egg production parameters of brown and white Hy-Line strains from 20 to 24 weeks of age.

	Strain		
Trait	Brown	White	Prob.
Body weight, g (20wk)	1412.88[a]	1113.34[b]	
	±7.14	±8.01	0.0001
Body weight, g (24wk)	1529.71[a]	1258.39[b]	
	±7.97	±8.32	0.0001
Egg mass, g	590.02	555.92	
	±30.48	±30.80	NS
Egg number	12.03	12.38	
	±0.63	±0.067	NS
Egg weight, g	49.12[a]	44.87[b]	
	±0.36	±0.36	0.0001
Egg production rate, %	42.98	44.21	
	±2.27	±2.40	NS
Broken eggs, %	1.16	1.02	
	±0.30	±0.24	NS
Double yolk eggs, %	1.39	1.09	
	±0.55	±0.27	NS
Feed consumption, g	1934.94[a]	1699.28[b]	
	±39.20	±20.99	0.0001
Feed conversion ratio	3.47	3.28	
	±0.07	±0.06	NS

Table 2. Internal egg quality of brown and white Hy-line strains at 24 weeks of age.

	Strain		
Trait	Brown	White	Prob
Egg weight, g	53.61a	49.17[b]	
	±0.51	±0.33	0.0001
Albumen weight, g	35.36a	32.31[b]	
	±0.48	±0.28	0.0001
Albumen weight, %	66.43a	65.64[b]	
	±0.42	±0.28	NS
Albumen height, mm	10.67[a]	9.94[b]	
	±0.19	±0.16	0.003
Yolk weight, g	13.12[b]	12.38[a]	
	±0.21	±0.14	0.006
Yolk weight, %	24.51	25.19	
	±0.38	±0.28	NS
Yolk diameter, mm	3.68	3.71	
	±0.02	±0.02	NS
Yolk height, mm	18.36	18.43	
	±0.20	±0.22	NS

Table 3. Eggshell quality of brown and white Hy-line strains at 24 weeks of age.

	Strain		
Trait	Brown	White	Prob
Shell weight, g	4.87[a]	4.52[b]	
	±0.07	±0.05	0.0001
Shell weight, %	9.12	9.19	
	±0.15	±0.07	NS
Short axial, mm	42.40[a]	40.15[b]	
	±0.21	±0.09	0.0001
Long axial, mm	53.70[a]	52.34[b]	
	±0.20	±0.027	0.0001
Shape index	78.97[a]	76.39[b]	
	±0.37	±0.45	0.0001
Shell thickness, mm	0.35	0.35	
	±0.004	±0.003	NS

Table 4. Blood parameters of brown and white Hy-line strains at 24 weeks of age.

	Strain		
Trait	Brown	White	Prob
Total protein, mg/100ml	5.39	5.56	
	±0.19	±0.22	NS
Albumen, mg/100ml	3.07	3.31	
	±0.12	±0.18	NS
Globulin, mg/100ml	2.32	2.25	
	±0.16	±0.24	NS
Calcium, mg/100ml	18.92	19.40	
	±0.18	±0.24	NS
Phosphorus, mg/100ml	7.94	8.01	
	±0.32	±0.29	NS

Table 5. Coefficients of partial regression and constant for brown and white Hy-line strains (20-24 wk).

Strain	Constant	EM	ΔW	$BW^{0.75}$	R^2
Brown	-577.27	0.39	0.30	9.98	0.44
White	165.80	0.30	0.97	7.60	0.56

EM = egg mass ΔW = body weight change
BW0.75 = metabolic body weight R2 = rate of determination

Table 6. Phenotypic correlation coefficients for some quantitative traits with residual feed consumption (20-24wk).

	Strain	
Trait	Brown	White
Body weight, g (20wk)	0.57*	0.42
Body weight, g (24wk)	0.61*	0.50*
Egg mass, g	-0.25	-0.30
Egg number, No.	-0.25	-0.35
Broken eggs, %	0.12	-0.09
Double yolk eggs, %	0.20	0.03
Observed feed consumption, g	0.78**	0.63*
Expected feed consumption, g	0.34	0.41
Plasma total protein, mg/100 ml	-0.12	0.32
Plasma albumen, mg/100 ml	-0.15	-0.48*
Plasma globulin, mg/100 ml	0.09	0.66**
Plasma calcium, mg/100 ml	0.09	0.58*
Plasma phosphorus, mg/100 ml	-0.19	-0.13
Albumen, %	0.11	0.47*
Yolk, %	0.33	0.49*
Shell, %	0.07	0.08
Shell thickness, mm	0.11	0.47**

* P<0.05 ** P<0.01

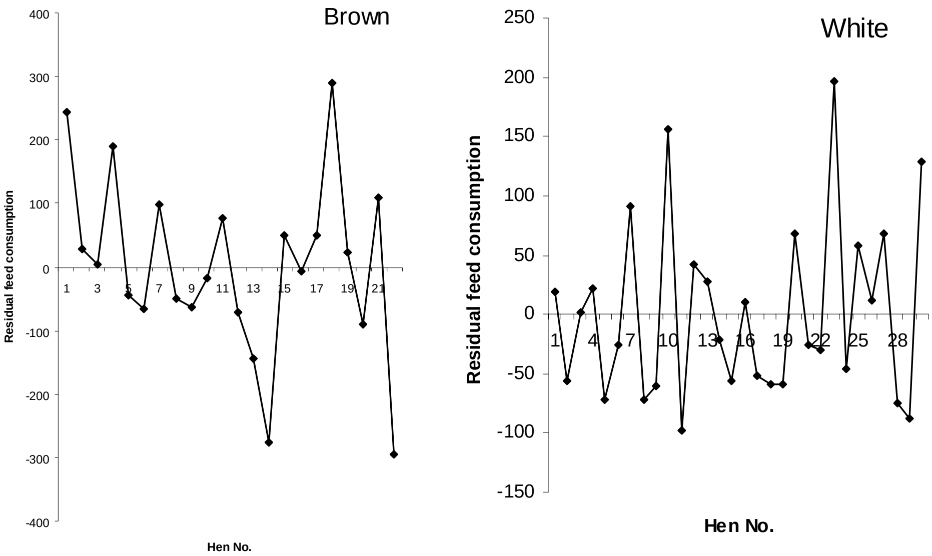

Fig.1. Residual feed consumption for brown and white Hy-line strains from 20 to 24 weeks of age.

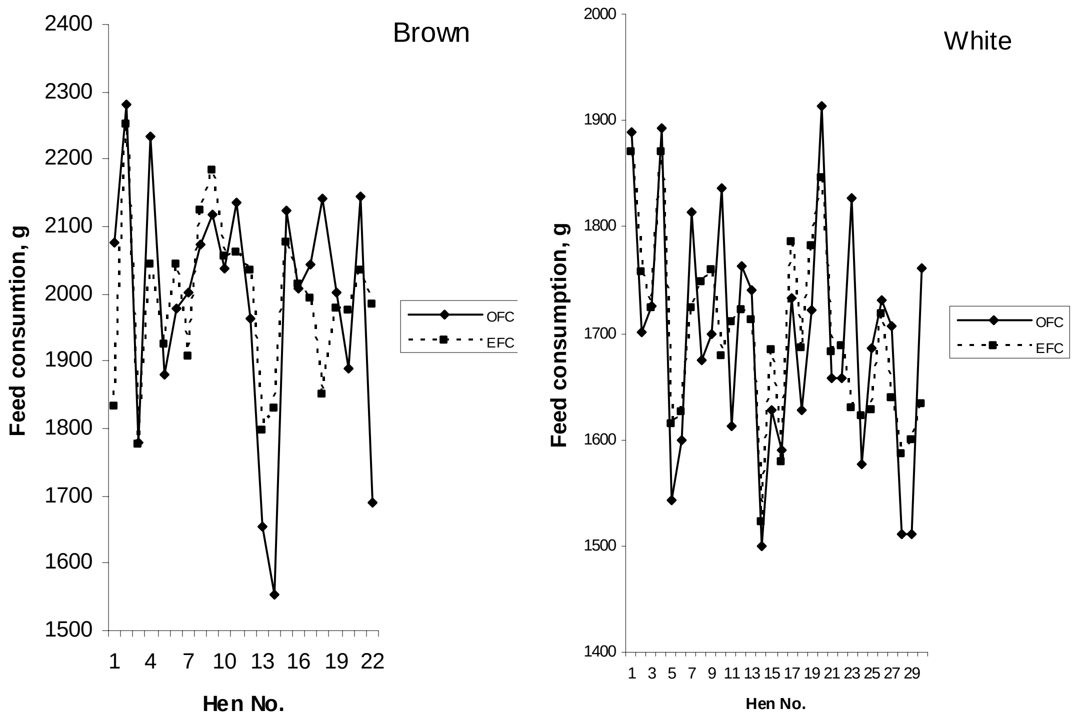

Fig.2. Observed vs. expected feed consumption for brown and white Hy-line strain from 20 to 24 weeks of age.

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الملخص العربي

الاستهلاك الغذائي المتوقع والعلف المتبقي في الدجاجات البياضة

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صممت هذه التجربة لتقدير الاستهلاك الغذائي المتوقع والعلف المتبقي في سلالتي الهاى لاين الأبيض و البني – استخدم في هذه التجربة عدد ٢١٠ دجاجة من سلالة الهاى لاين (١٢٠ دجاجة بيضاء، ٩٠ دجاجة بنية). استمرت الفترة التجريبية من عمر ٢٠ أسبوع وحتى ٢٤ أسبوع. تم وضع الدجاجات تحت نفس الظروف من حيث العوامل البيئية والرعاية الصحية. وكانت أهم النتائج المتحصل عليها كما يلي:-

- سجلت الدجاجات البنية وزن جسم اثقل معنويا من الدجاجات البيضاء.
- أنتجت الدجاجات البنية بيض اثقل معنويا من الدجاجات البيضاء.
- سجلت الدجاجات البيضاء معدلات إنتاج بيض أعلى من الدجاجات البنية.

- استهلكت الدجاجات البنية كمية علف أعلى معنويا من الدجاجات البيضاء. بينما سجلت الدجاجات البيضاء معدلات تحويل غذائي افضل من الدجاجات البنية.
- سجلت معادلة الانحدار المحسوبة للدجاجات البيضاء معامل تحديد (R^2) افضل من الأخرى المسجلة للدجاجات البنية.
- تقترب قيم العلف الغذائي المشاهد من قيم العلف الغذائي المتوقع في الدجاجات البيضاء مقارنة بالدجاجات البنية.
- وجد ارتباط معنوي موجب بين وزن الجسم والعلف الغذائي المتبقي في كلا السلالتين.
- شوهد ارتباط سالب بين كل من كتلة البيض وعدد البيض مع العلف الغذائي المتبقي في كلا السلالتين.
- سجل الارتباط بين جلوبيولين البلازما والعلف الغذائي المتبقي قيما معنوية موجبة في السلالة البيضاء بينما كانت هذه القيم موجبة ومنخفضة في السلالة البينة.
- وجد ارتباط معنوي سالب بين البيومين البلازما والعلف الغذائي المتبقي في سلالة الهاى لاين البيضاء
- يوجد ارتباط معنوي موجب بين نسبة الصفار والعلف الغذائي المتبقي في سلالة الهاى لاين الأبيض. بينما شوهد نفس الارتباط في سلالة الهاى لاين البنية مع عدم وجود معنوية.
- وجد ارتباط معنوي موجب بين سمك القشرة والعلف الغذائي المتبقي في سلالة الهاى لاين الأبيض، بينما كانت هذه القيمة منخفضة في سلالة الهاى لاين البني.

الخلاصة: أوضحت النتائج المتحصل عليها انه يجب الاهتمام بأن تؤخذ في الاعتبار الاختلاف بين القطعان الوراثية بشأن احتياجاتها الحافظة والإنتاجية (إنتاج البيض) كما أوضحت النتائج انه من المحتمل استعمال معامل الانحدار التدريجي في الانتخاب لتحسين الكفاءة الغذائية للاحتياجات الحافظة و إنتاج البيض.