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Genetic Correlation of Product, Egg Quality and Biochemical Traits of Lohmann Brown Laying Hens

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ABSTRACT

This study conducted in College of Agriculture - University of Kirkuk from 1/5/2024 to 6/8/2024, to study the genetic correlation of productive, egg quality and biochemical traits of laying hens. One hundred twenty Lohmann Brown laying hens aged 64 weeks, housed in vertical battery cages. Each battery contained 4 floors, and each floor contained 3 cages. The dimensions of each cage were (35 x 30 x 40 cm). The results indicated a negative and significant genetic correlation between blood cholesterol level and EP rate, EW and EM, while the genetic correlation was positive and significant between cholesterol and the FCR. A negative and significant genetic correlation was also recorded between the AST enzyme in the blood and EP rate, EW and EM, while the genetic correlation was positive and significant between the AST enzyme and the FCR. On the other hand, a positive and highly significant genetic correlation was observed between the cholesterol level in the blood and the yolk index, as well as a positive and significant genetic correlation between the AST enzyme and the two traits of the yolk index and the shell thickness. Thy study recommends using indirect genetic improvement programs based on some biochemical traits in blood serum (glucose, total protein, cholesterol, AST and ALT enzymes) due to their positive and significant correlation with productive performance and egg quality traits in laying hens.

***Keywords*:** Combine, Reel, Wheat, threshing, Cleaning, losses.

INTRODUCTION

Laying chickens are one of the most important sources of animal protein production, especially through eggs, which are considered a basic food rich in proteins, vitamins and minerals [1]. Due to the increasing demand for eggs as an economical and healthy food source, laying hens have received great attention in genetic improvement programs [2], aimed at increasing production efficiency and improving egg quality, while maintaining the overall health of the bird [3]. Genetic traits in laying hens are the cornerstone of determining a flock's productive performance [4]. Furthermore, the importance of physiological and biochemical blood traits has emerged as genetic indicators that contribute to assessing the productive status of birds, which contributes to improving the early selection process for highly efficient individuals [5]. The study of the genetic relationship between EP and quality traits and blood biochemical traits in laying hens is of great importance in genetic improvement and selective breeding programs [6]. Several studies indicate varying positive and negative genetic correlations between these traits, allowing some traits to be used as indirect indicators for improving others [7]. Some studies have shown genetic correlations between certain biochemical traits and production traits, [8] indicated a positive genetic correlation between higher total blood protein concentrations and increased EP. [9] also found that some liver enzymes are negatively correlated with egg quality traits, indicating the impact of physiological stress on production. [10] pointed that using biochemical traits as early indicators in genetic selection saves time and costs compared to relying exclusively on production traits that do not appear until after sexual maturity. Therefore, incorporating biochemical analysis into genetic selection programs is a strategic step toward improving genetic efficiency and overall herd health [11]. In light of the above, enhancing understanding of the genetic relationships between these traits helps in developing more accurate and comprehensive breeding strategies that lead to improved quantitative and qualitative production, supporting the sustainability and profitability of the poultry industry.

Materials and Methods:

This study was carried out in College of Agriculture - University of Kirkuk from 1/5/2024 to 6/8/2024, to study the genetic correlation of productive, egg quality and biochemical traits of laying hens. 120 Lohmann Brown laying hens aged 64 weeks, divided into 6 treatments, 5 replicates, 4 hens per replicate placed in vertical battery cages. Each battery contained 4 floors, each floor contained 3 cages, the dimensions of each cage were (35 x 30 x 40 cm). Table (1) below shows the experimental diet.

Table (1) the experimental diet.

Contents	%
Wheat	16.32
Corn	40.5
Oil	1
Barley	4
Soybean 48%	25.7
Laymix-2.5	2.5
Lysine	0.01
Methionine	0.07
Limestone	9
T. Salt	0.2
Choline Chloride	0.25
DCP	0.45
Total	100 %
chemical composition[1]	
ME/CP Ratio	167.03
M.E. Kcal/kg	2708
Protein %	18.37
Lysine %	1
Methionine	0.47
Methionine and Cysteine %	0.69
Ca %	4.38
p %	0.6

[1] According to NRC, 1994

The correlation coefficients between the traits were calculated based on the formula described by [12]. Biochemical analyses of the blood samples were conducted using a spectrophotometer in the advanced laboratory of the College of Agriculture, University of Kirkuk.

$$r = \frac{dn(\sum xy) - (\sum x)(\sum y)}{\sqrt{n(\sum x2) - (\sum x)2} \, . \, \sqrt{n(\sum y2) - (\sum y)2}}$$

Results and Discussion:

Genetic correlation between production and egg quality traits:

genetic correlation between productive and qualitative traits of laying hens was shown in table (2), a negative and insignificant genetic correlation between the egg shape index, EP, and EM, which reached (-0.137 and -0.045), sequentially. While a positive and insignificant genetic correlation was observed between the egg shape index, EW and FCR, which reached (0.101 and 0.047) sequentially. As for the albumin index trait, the table shows a negative and insignificant genetic correlation between albumin index, EP and EW, which reached (-0.169, -0.107 and -0.154) sequentially. While a positive and insignificant genetic correlation was evident between albumin index and FCR, which reached 0.171. As for the yolk index trait, the table shows a negative and insignificant genetic correlation between the yolk index and EP, EW and EM, amounting to (-0.308, -0.321 and -0.341) sequentially, while a positive and insignificant genetic correlation is observed between the yolk index and the FCR, amounting to 0.374.

Table (2): The genetic correlation between productive and egg quality traits of laying hens.

productive traits egg quality traits	EP (%)	EW (g)	EM (g eggs/bird/day)	FCR (g feed/g eggs)
Egg shape index (%)	0.137-	0.101	0.045-	0.047
Albumin Index (%)	0.169-	0.107-	0.154-	0.171
Yolk index (%)	0.308-	0.321-	0.341-	0.374
Albumin weight (%)	0.053	0.122	0.089	0.088-
Yolk weight (%)	0.026-	0.115-	0.069-	0.067
Shell weight (%)	0.081-	0.111-	0.103-	0.103
Hugh unit	0.187-	0.174-	0.195-	0.213
Shell thickness (mm)	0.264-	0.264-	0.292-	0.280

EP=Egg Production, EW= Egg Weight, EM= Egg Mass, FCR= Feed Convertino Ratio.

As for the percentage of egg white weight, the table shows a positive and insignificant genetic correlation between the percentage of egg white weight and EP, EW and EM, which reached (0.053, 0.122 and 0.089) sequentially, while the genetic correlation was negative and insignificant between the percentage of egg white weight and the FCR, which reached -0.088. As for the yolk weight percentage trait, there is a negative and insignificant genetic correlation between the yolk weight percentage and EP, EW and EM, which reached (-0.026, -0.115 and -0.069) sequentially, while the genetic correlation was positive and insignificant between the yolk weight percentage and the FCR, which amounted to 0.067. As for the shell weight percentage trait, there is a negative and insignificant genetic correlation between the shell weight percentage and EP, EW and EM, which amounted to (-0.081, -0.111 and -0.103) sequentially, while there is a positive and insignificant genetic correlation between the shell weight percentage and the FCR, which amounted to 0.103. As for the trait of hugh unit, the table shows that there is a negative and insignificant genetic correlation between it and EP, EW and EM, amounting to (-0.187, -0.174 and -0.195) sequentially, while the genetic correlation was positive and insignificant between hugh unit and the FCR, amounting to 0.213. As for the shell thickness trait, the table shows a negative and insignificant genetic correlation between shell thickness and EP, EW, and EM, amounting to (-0.264, -0.264, and -0.292), sequentially. Meanwhile, the genetic correlation was positive and insignificant between shell thickness and the FCR, amounting to 0.280.

Genetic correlation between blood biochemical and productive traits:

Table (3) shows genetic correlation between the blood biochemical traits and the productive traits of laying hens. There is a negative and insignificant genetic correlation between glucose and EP, EW and EM, which amounted to (-0.351, -0.357 and -0.378) sequentially, while a positive and insignificant genetic correlation is observed between glucose and the FCR, which amounted to 0.377. As for the total protein trait, the table shows a positive and insignificant genetic correlation between the total protein and EP, EW and EM, amounting to (0.068, 0.031 and 0.058) sequentially, while the genetic correlation was negative and insignificant between the total protein and the FCR, amounting to -0.051. As for the globulin trait, there is a positive and insignificant genetic correlation between globulin and EP, EW and EM, which amounted to (0.068, 0.031 and 0.058) sequentially, while the genetic correlation was negative and insignificant between the globulin level and the FCR, which amounted to -0.051. About albumin trait, the table shows a positive and insignificant genetic correlation between albumin and EP, EW, and EM, which reached (0.068, 0.031, and 0.058), sequentially, while the genetic correlation was negative and insignificant between albumin and the FCR, which reached -0.051. For the cholesterol trait, the table shows a negative and significant genetic correlation between cholesterol and EP and EM, which reached (-0.469 and -0.484) sequentially. It also shows a positive and significant genetic correlation between cholesterol and the FCR, which reached 0.484, while a negative and insignificant genetic correlation is observed between cholesterol and EW, which reached -0.430. As for AST enzyme, the table showed a negative and significant genetic correlation between it and EP, EW, and EM, which amounted to (-0.527, -0.570, and -0.581), sequentially, while the genetic correlation was positive and significant between the AST enzyme and the FCR, which amounted to 0.579. About HDL, the table shows a positive and insignificant genetic correlation between HDL and EP, EW, and EM, which amounted to (0.166, 0.297, and 0.233), sequentially, while the genetic correlation was negative and insignificant between HDL and the FCR, which amounted to -0.231. For LDL, the table shows a negative and insignificant genetic correlation between them and EP, EW, and EM, which amounted to (-0.229, -0.161, and -0.215), sequentially, while the genetic correlation was positive and insignificant between LDL and the FCR, which amounted to 0.216. As for ALT enzyme, there was a negative and insignificant genetic correlation between it and EP, EW, and EM, which amounted to (-0.142, -0.044, and -0.111), sequentially, while the genetic correlation was positive and insignificant between it and the FCR, which amounted to 0.107.

Table (3): Genetic correlation between blood biochemical and production traits of laying hens

production traits biochemical traits	EP (%)	EW (g)	EM (g eggs/bird/day)	FCR (g feed/g eggs)
Glucose	0.351-	0.357-	0.378-	0.377
Total protein	0.068	0.031	0.058	0.051-
Globulin	0.068	0.031	0.058	0.051-
Albumin	0.068	0.031	0.058	0.051-
Cholesterol	0.469-	0.430-	*0.484-	0.484
AST	0.527-	0.570-	*0.581-	*0.579
HDL	0.166	0.297	0.233	0.231-
LDL	0.229-	0.161-	0.215-	0.216
ALT	0.142-	0.044-	0.111-	0.107

• * Indicates a genetic correlation at the 5% level. EP=Egg Production, EW= Egg Weight, EM= Egg Mass, FCR= Feed Convertino Ratio, AST= Aspartate Aminotransferase, HDL= High Density Lipoprotein, LHL= Low Density Lipoprotein, ALT= Alanine transaminase.

[13] indicated that the negative genetic correlation between blood cholesterol levels and EP in chickens indicates that birds with high production efficiency tend to direct their metabolic resources more towards supporting the vital processes associated with EP, such as egg yolk formation and the synthesis of proteins and hormones necessary for ovulation, rather than storing fat or producing excess amounts of cholesterol. High blood cholesterol levels may also reflect a hormonal imbalance, such as a disorder in estrogen production, or indicate poor metabolic efficiency, leading to cholesterol accumulation instead of being utilized for its vital functions [14]. All of these factors combined may reduce the efficiency of the reproductive system and impair a bird's ability to produce eggs regularly and abundantly [15]. Therefore, this negative correlation appears to be a genetic trait linked to productive performance. On the other hand, [11] pointed out that the liver is the primary organ responsible for many vital functions that support EP in chickens, such as protein synthesis, the production of phospholipids necessary for the formation of egg yolk, and hormone regulation. When EP is at its peak, the liver operates at high efficiency to meet these demands without experiencing stress or damage, resulting in its enzyme levels (such as AST and ALT) remaining within the normal range in the blood [3]. Therefore, low levels of liver enzymes in the blood of high-producing chickens do not mean that the liver is not functioning, but rather that it is operating at high efficiency without cellular damage [11]. This is an indirect indicator of liver health and metabolic balance, which positively impacts EP capacity.

Genetic correlation between blood biochemical and egg quality traits:

Table (4) shows the genetic correlations between the blood biochemical traits and egg quality traits of laying hens. There is a positive and insignificant genetic correlation between glucose and egg shape index, albumin index, hugh unit and shell thickness, which amounted to (0.165, 0.055, 0.050 and 0.238) sequentially, while the genetic correlation was positive and significant between the glucose level and yolk index, which amounted to 0.488. As for the total protein, it is clear from the table that there is a negative and insignificant genetic correlation between the total protein and the egg shape index, the yolk index, and the shell thickness, if it reached (-0.234, -0.149, and -0.108), sequentially, while the genetic correlation was positive and insignificant between the total protein and the albumin index and hugh unit, amounting to (0.332 and 0.361), sequentially. About globulin in blood, the table shows a negative and insignificant genetic correlation between the level of globulin and the egg shape index, yolk index, and shell thickness, which amounted to (-0.234, -0.149, and -0.108), sequentially, while genetic correlation was positive and insignificant between the level of globulin and the albumin index and hugh unit, which amounted to (0.332 and 0.361), sequentially. As for the level of albumin in the blood, there was a negative and insignificant genetic correlation between the level of albumin and the egg shape index, yolk index and shell thickness, which amounted to (-0.234, -0.149 and -0.108) sequentially, while the genetic correlation was positive and insignificant between the level of albumin and the albumin index and hugh unit, which amounted to (0.332 and 0.361). As for the blood cholesterol trait, the table shows a positive and insignificant genetic correlation between the blood cholesterol level and the egg shape index, albumin index, hugh unit, and the shell thickness, which reached (0.142, 0.304, 0.329, and 0.243), sequentially, while the genetic correlation was positive and highly significant between the blood cholesterol level and the yolk index, which reached 0.598. About AST enzyme, there is a positive and insignificant genetic correlation between it and egg shape index, albumin index, and hugh unit, which reached (0.250, 0.117, and 0.042), sequentially, while the genetic correlation was positive and significant between AST enzyme and yolk index and shell thickness, which reached (0.484 and 0.529), Sequentially. As for HDL, the table shows a positive and insignificant genetic correlation between it and the egg shape index, which amounted to (0.287), while the genetic correlation was negative and insignificant between HDL and the albumin index, yolk index, hugh unit, and shell thickness, which amounted to (-0.075, -0.029, -0.034, and -0.245), sequentially. About LDL, the table shows a positive and insignificant genetic correlation between it and the egg shape index, albumin index, hugh unit, and shell thickness, which amounted to (0.360, 0.151, 0.150, and 0.039), sequentially, while the genetic correlation was positive and significant for LDL and the yolk index, which amounted to 0.523. As for ALT enzyme, the table shows a positive and insignificant genetic correlation between it and egg shape index and yolk index, which amounted to (0.106 and 0.375) sequentially, while the genetic correlation was negative and insignificant between the ALT enzyme and albumin index and hugh unit, which amounted to (-0.198 and -0.153) sequentially, while the genetic correlation was positive and significant between the ALT enzyme and shell thickness, which amounted to 0.538. [16] appointed that Glucose is the primary source of energy for chickens and plays a vital role in supporting metabolic processes in the liver, the organ responsible for synthesizing the proteins and lipids that make up egg yolk. Adequate glucose availability enhances the liver's ability to efficiently synthesize these components, which positively impacts yolk quality and increases yolk index, Furthermore, glucose metabolism is linked to the regulation of hormones such as insulin and estrogen, with estrogen playing a key role in stimulating yolk formation [11]. Therefore, birds with greater metabolic efficiency in glucose utilization may exhibit better yolk quality due to a favorable hormonal balance and supportive metabolic environment [2]. On the other hand, [14] explained that cholesterol is a key component of egg yolk, as it is involved in the formation of very low-density lipoproteins (VLDL), which are produced in the liver and transported to the ovaries to form the yolk, these lipoproteins are rich in cholesterol and triglycerides and are the primary source of structure and energy needed for yolk growth.

Table (4): Genetic correlation between biochemical blood and egg quality traits of laying hens.

egg quality traits / biochemical traits	Egg shape index (%)	Albumin Index (%)	Yolk index (%)	Hugh unit	Shell thickness (mm)
Glucose	0.165	0.055	0.488	0.050	0.238
Total protein	0.234-	0.332	0.149-	0.361	0.108-
Globulin	0.234-	0.332	0.149-	0.361	0.108-
Albumin	0.234-	0.332	0.149-	0.361	0.108-
Cholesterol	0.142	0.304	0.598	0.329	0.243
AST	0.250	0.117	0.484	0.042	0.529
HDL	0.287	0.075-	0.029-	0.034-	0.245-
LDL	0.360	0.151	*0.523	0.150	0.039
ALT	0.016	0.198-	0.375	0.153-	0.538

• * Indicates a genetic correlation at the 5% level.
• ** Indicates a genetic correlation at the 1% level.
AST= Aspartate Aminotransferase, HDL= High Density Lipoprotein, LHL= Low Density Lipoprotein, ALT= Alanine transaminase.

Therefore, high blood cholesterol levels reflect a greater metabolic capacity to form and transport yolk components, which contributes to improving its physical properties (such as texture and consistency), thus increasing the yolk index

[15]. Aspartate aminotransferase (AST) is a biomarker of liver activity, it is involved in amino acid conversion, and its elevation (within normal limits) indicates high metabolic efficiency [3]. This metabolic activity supports vital processes associated with egg component production, such as the synthesis of proteins and very low-density lipoproteins (VLDLs), which are transported to the ovary to form the yolk, contributing to improved yolk quality and higher yolk index [15]. The liver is also a key axis in regulating calcium and phosphorus metabolism, two vital components of eggshell formation. This means that birds with high liver efficiency are better able to support the formation of a thicker, more robust shell [17].

Recommendations:

Indirect genetic improvement programs can be implemented based on certain biochemical traits in blood serum such as glucose, total protein, cholesterol, and the enzymes AST and ALT due to their positive and significant correlations with productive performance and egg quality traits in laying hens.

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الارتباط الوراثي بين الصفات الإنتاجية والنوعية للبيض والصفات الكيموحيوية للدم للدجاج البياض سلالة لوهمان البني

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الخلاصة

أُجريت الدراسة في حقل الدواجن التابع لقسم الإنتاج الحيواني - كلية الزراعة - جامعة كركوك، للفترة من 2024/5/1 إلى 2024/8/6، لدراسة الارتباط الوراثي بين الصفات الإنتاجية وجودة البيض والصفات البيوكيميائية لدم الدجاج البياض. استخدمت الدراسة 120 دجاجة بياضة من نوع لوهمان البني، بعمر 64 أسبوعًا، وضعت في أقفاص بطاريات عمودية. احتوت كل بطارية على 4 طوابق، وكل طابق يحتوي على 3 أقفاص. كانت أبعاد كل قفص (35 × 30 × 40 سم) طولًا وعرضًا وارتفاعًا، على التوالي. أشارت النتائج إلى وجود ارتباط وراثي سلبي ومعنوي بين مستوى الكوليسترول في الدم ومعدل إنتاج البيض ووزن البيضة وكتلة البيض، بينما كان الارتباط الوراثي إيجابيًا ومعنويًا بين الكوليسترول ومعامل التحويل الغذائي. كما سُجل ارتباط وراثي سلبي ومعنوي بين إنزيم ***AST*** في الدم ومعدل إنتاج البيض ووزن البيضة وكتلة البيض، بينما كان الارتباط الوراثي إيجابيًا ومعنويًا بين إنزيم ***AST*** ومعامل التحويل الغذائي. ومن ناحية أخرى، لوحظ وجود ارتباط وراثي موجب عالي المعنوية بين مستوى الكوليسترول في الدم ودليل الصفار، وكذلك وجود ارتباط وراثي موجب ومعنوي بين أنزيم ***AST*** وكل من صفتي دليل الصفار وسمك القشرة

الكلمات المفتاحية: حاصدة، مرواح، قمح، فصل، تنظيف، خسائر الارتباط الوراثي، الصفات الإنتاجية، جودة البيض، الصفات الكيموحيوية، لوهمان.