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Egg Production and Blood Lipid Profile Comparison Between Local Stock (Elba Chickens) and Commercial Stock (Hy-Line Brown)

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ABSTRACT

This study compared egg production performance and blood lipid profiles between local (Elba) and commercial (Hy-Line Brown) chickens. A total of 120 hens (18 wk of age) were used, with chicken breed as the treatment factor and 60 replicates per treatment. Each hen served as an experimental unit and was housed individually in a battery cage. The experiment was conducted over a 12-wk period, from 18 to 30 wk of age, under controlled environmental conditions. Parameters measured included number of eggs (NE), hen-day average (HDA), egg weight (EW), daily feed intake (DFI), egg mass (EM), and feed conversion ratio (FCR). Blood samples were collected at 28 wk of age to analyze total cholesterol, triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and glucose levels. Data was analyzed using an independent samples t-test. Results indicated that local chickens had significantly lower performance across all production parameters compared to commercial chickens ($p<0.01$). Specifically, local chickens exhibited lower NE (39.13 ± 3.30 vs. 53.45 ± 2.21 eggs/hen), HDA (65.22 ± 5.50% vs. 89.10 ± 3.73%), EW (45.47 ± 1.21 vs. 60.57 ± 1.71 g), DFI (71.72 ± 6.35 vs. 108.63 ± 8.69 g/hen/day), and EM (25.70 ± 4.41 vs. 53.97 ± 2.71 g/hen). Consequently, local chickens had a significantly poorer FCR than commercial chickens (2.86 ± 0.46 vs. 2.02 ± 0.17, $p<0.01$). Regarding blood profiles, local chickens displayed significantly higher levels of cholesterol (120.38 ± 37.41 vs. 98.84 ± 15.21 mg/dL, $p = 0.02$), triglycerides (213.55 ± 47.99 vs. 100.23 ± 23.49 mg/dL, $p<0.001$), glucose (187.89 ± 30.79 vs. 164.21 ± 21.13 n HDL levels ($p = 0.14$). A strong negative correlation was found between egg production and triglyceride levels ($r = -40.8368$, $p<0.001$). These findings show that local chickens possess significantly lower production efficiency and a distinct lipid metabolism profile compared to commercial stock, largely due to the lack of intensive selective breeding for productivity traits.

KEYWORDS

Egg production; Blood lipid profiles; Commercial chicken; Local chicken

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1. Introduction

The genetic background of chicken breeds plays an important role in their phenotypic characteristics and performance traits, particularly in egg production. Elba chickens are a local breed, while the Hy-Line Brown is a commercial strain. These breeds exhibit distinct genetic profiles that influence their adaptability and productivity. Studies indicate that indigenous chicken breeds, such as the Elba, generally exhibit lower genetic diversity than commercial breeds, which have been selectively bred for specific traits such as egg production and growth rate (Malomane et al., 2019). The genetic relationships among various chicken breeds, including both local and commercial types, demonstrate the effects of domestication and selective breeding on their genetic makeup and subsequent performance (Rubin et al., 2010; Qanbari et al., 2019).

Phenotypically, Elba chickens are characterized by traits typical of local breeds, such as smaller body size and varied plumage coloration, which are attributed to their adaptation to local environments (Falculan, 2023; Park et al., 2013). In contrast, Hy-Line Brown chickens are bred for uniformity in size and color, as well as enhanced egg-laying capabilities. These phenotypic distinctions reflect underlying genetic adaptations resulting from selective breeding over multiple generations. Studies have demonstrated that commercial breeds have undergone significant genetic modifications to optimize traits such as egg production, feed efficiency, and disease resistance, which are less pronounced in local breeds like the Elba (Xu, 2023; Malomane et al., 2021).

Performance traits, especially egg production, further distinguish these two breeds. Hy-Line Brown chickens are recognized for their high egg yield, a result of specialized selective breeding focused on enhancing reproductive efficiency (Nie et al., 2019; Qanbari et al., 2019). In contrast, Elba chickens, while potentially more resilient to local environmental stressors, typically exhibit lower egg production rates. This performance gap is often associated with their specific adaptive strategies, which are tailored for survival rather than intensive production (Xu, 2023; Sha et al., 2020). This study posits that local chickens have not yet achieved production yields comparable to those of commercial breeds, largely due to the limited selective breeding historically applied to indigenous stocks. Consequently, these results provide current information on the performance records of Elba chickens relative to commercial breeds. This data is expected to inform the development of future breeding strategies to improve the genetic quality and productivity of local chickens while preserving their unique environmental adaptability.

2. Materials and Methods

2.1. Experimental animals

A total of 120 female chickens were used in this study, divided into two treatment groups: 60 commercial-stock Hy-Line Brown chickens and 60 local-stock Elba chickens. All birds were 18 wk old at the start of the experiment.

The hens were selected to represent two distinct production systems: a high-yielding commercial line and a local Indonesian breed. At the onset of the study (18 wk of age), the average body weight for the Hy-Line Brown group was approximately 1.45 kg (range: 1.35–1.55 kg), while the Elba chickens, characterized by a smaller body size, had an average body weight of approximately 1.2 kg (range: 1.15–1.25 kg).

2.2. Experimental design

2.2.1. Housing and management

The birds were housed in a closed-sided poultry house and individually accommodated in galvanized battery cages (45 cm length × 40 cm width × 35 cm height). This individual housing system was used to precisely monitor daily feed intake and egg production in each experimental unit. Each cage was equipped with a manual trough-type feeder and an individual nipple drinker to ensure continuous and hygienic access to water.

The birds were maintained under a controlled photoperiod consisting of 16 hours of light and 8 hours of darkness to optimize reproductive performance. Environmental conditions were regulated via mechanical ventilation to maintain a constant ambient temperature between 20–25°C and a relative humidity of approximately 60%. Feed was provided manually twice daily, while water was supplied ad-libitum through a centralized piping system. Waste was removed from the facility daily to maintain sanitary conditions and minimize ammonia accumulation.

2.2.2. Diet and nutrition

The experimental diet was formulated using a mixture of yellow corn, rice bran, and a commercial protein concentrate. The feed was provided in mash form, and the birds had *ad libitum* access to both feed and water throughout the study. The feed composition and the calculated nutrient levels are presented in **Table 1**.

Table 1. Feed composition and nutrient content of the experimental diet

Ingredients	Inclusion level (%)
Yellow Corn	50
Rice Bran	25
Protein Concentrate[1]	25
Total	**100**
Calculated nutrients[2]	
Metabolizable Energy	2.900
Crude Protein (%)	16.5
Crude Fat (%)	3.8
Crude Fiber (%)	4.2
Calcium (%)	3
Available Phosphate	1.6
Lysine (%)	0.8
Methionine (%)	0.4
Threonine (%)	0.7

[1] *The protein concentrate (composed of soybean meal and fish meal) included a vitamin-mineral premix and flaxseed (0.3%).*
[2] *Nutrient levels were determined based on the calculated values of the individual ingredients according to the feed composition table.*
[3] *Micronutrient and supplement contents per kg of diet: Vitamin A (9000 IU), Vitamin D3 (2000 IU), Vitamin E (100 IU), Vitamin K (3 mg), B-complex vitamins (B1, B2, B6, B12), Magnesium (0.05%), Zinc (60 ppm), Copper (10 ppm), and Manganese (60 ppm).*

2.3. Data collection and research parameters

Data was collected daily for 12 consecutive wk (from 18 to 30 wk of age). The parameters measured were categorized into two primary groups:

2.3.1. Egg production performance.

Daily feed intake (DFI): Feed was weighed before being offered to each hen daily, and the orts (refusal) were weighed the following morning. DFI was calculated as the difference between the feed offered and the orts, expressed in grams per bird per day (g/bird/day).

Egg weight (EW): All eggs produced daily were weighed individually using a digital scale with 0.01 gr precision. The average egg weight is expressed in grams per egg (g/egg).

Hen-day production (HDP): The number of eggs produced was recorded daily. HDP was calculated using the following formula:

$$HDP\ (\%) = \frac{Total\ number\ of\ eggs\ produced\ in\ a\ day}{Total\ number\ of\ living\ hens\ in\ that\ day} \times 100$$

Egg mass (EM): Egg mass was calculated to combine production rate and egg size into a single value, expressed in grams per bird:

$$EM\left(\frac{g}{bird}\right) = \frac{HDP\ (\%) \times average\ egg\ weight\ (g)}{100}$$

Feed conversion ratio (FCR): This was calculated as the efficiency of the hen in converting feed into egg mass:

$$FCR = \frac{daily\ feed\ intake\ (g)}{egg\ mass\ (g)}$$

Table 2. Comparison of egg production and feed efficiency between local (Elba) and commercial (Hy-Line Brown) chickens during the first 12 wk of production (18–30 wk of age).

Parameters	T2 (Hy-Line)	T1 (Elba)	T-value	P-value
NE (egg/hen)	53.45 ± 2.21^a	39.13 ± 3.30^b	29.23	0.00
HDA (%)	89.10 ± 3.73^a	65.22 ± 5.50^b	29.33	0.00
EW (g/egg)	60.57 ± 1.71^a	45.47 ± 1.21^b	53.37	0.00
DFI (g/hen/day)	108.63 ± 8.69^a	71.72 ± 6.35^b	75.82	0.00
EM (g/hen)	53.97 ± 2.71^a	25.70 ± 4.41^b	45.62	0.00
FCR	2.02 ± 0.17^b	2.86 ± 0.46^a	14.15	0.00

Data are expressed as mean ± Standard deviation (SD). a, b Mean values with different superscripts in the same column indicate a significant difference ($p \leq 0.05$). NE: Number of egg production. HDA: Hen day production. EW: Egg weight. DFI: Daily feed intake. EM: Egg mass. FCR: Feed conversion ratio.

Blood profile analysis. At 28 wk of age, blood samples were collected from the wing vein (Vena brachialis) of all 120 birds (60 per group) using sterile 3 mL syringes. Samples were transferred into tubes containing EDTA as an anticoagulant for plasma separation. The blood plasma was separated by centrifugation at 3.000 rpm for 10 minutes and stored at -20°C. The following biochemical parameters were measured using an automated analyzer and standard enzymatic-colorimetric kits: total cholesterol, triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and glucose.

2.4. Statistical analysis

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 25.0. To compare the means of the local Elba chickens and the commercial Hy-Line Brown chickens, a t-test for independent samples was employed. This statistical method was selected because the study involved only two treatment groups, rendering an Analysis of Variance (ANOVA) and subsequent post-hoc tests unnecessary.

The results are expressed as Mean ± Standard Deviation (SD). Statistical significance was defined at $p<0.05$, with $p<0.01$ indicating highly significant differences. Correlation analysis between egg production and blood lipid parameters was performed using Pearson's correlation coefficient (r).

3. Results and Discussion

3.1. Egg production performance and feed efficiency

The comparative performance of local Elba chickens and commercial Hy-Line Brown chickens is summarized in **Table 2**. The results indicate that while Elba chickens are a valued local genetic resource, their production parameters currently lag significantly behind commercial benchmarks due to the lack of intensive selection for high-yield traits.

3.2. Hen-day production (HDP)

Elba chickens exhibited a hen-day production (HDP) of 65.22 ± 5.50%, which was significantly lower ($p<0.01$) than the 89.10 ± 3.73% recorded for the Hy-Line Brown chickens. The HDP was monitored during the early production phase (18–30 wk); while production typically increases in both breeds as they approach peak maturity, the local Elba chickens consistently demonstrated a lower laying rate. Since both breeds were maintained under identical environmental conditions and nutritional management, the 23.88% gap in HDP is primarily attributable to genetic divergence. Commercial stocks like the Hy-Line Brown have undergone decades of rigorous selection for persistent laying cycles, whereas Elba chickens retain more natural, less intensive reproductive cycles adapted for survival (El-Tahawy and Habashy, 2021). This lower HDP aligns with data from other local breeds, which frequently show lower egg-laying frequencies compared to exotic strains (Amao, 2024; Tadesse et al., 2013). The weekly progression of HDP (**Figure 1**) shows that Hy-Line Brown chickens reached peak production sooner and maintained a higher plateau than the Elba breed.

3.3. Egg weight (EW)

The average weight of eggs produced by Elba chickens was 45.47 ± 1.21 g, significantly lower ($p<0.01$) than the 60.57 ± 1.71 g observed in the commercial group. Egg weight is highly heritable, and the smaller egg size in Elba chickens is characteristic of many Indonesian indigenous breeds. This lower weight is linked to the smaller body size of the Elba hen and a physiological trade-off in which nutrients are allocated toward maintenance rather than to large-scale yolk and albumen deposition. These findings align with reports on other local strains, in which egg weights rarely exceed 50 g without genetic intervention (Khalil, 2020).

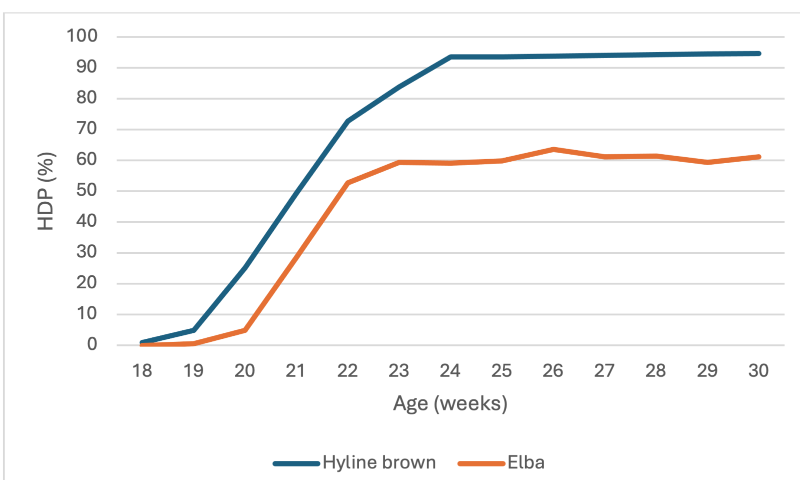

Figure 1. Comparison of Hen-Day Production (%) between Elba and Hy-Line Brown chickens from 18 to 30 wk of age.

Table 3. Comparison of blood parameters between local (Elba) and commercial (Hy-line) chickens

Treatment	Cholesterol	TG	HDL	LDL	Glucose	TC/HDL Ratio	LDL/HDL Ratio
T1 (Elba)	120.38±37.4[a]	213.55±47.99[a]	6.86±3.34[a]	1.28±0.61[a]	187.89±30.79[a]	17.55±5.45[a]	0.19±0.09[a]
T2 (Hy-line)	98.84±15.2[b]	100.23±23.49[b]	5.25±2.03[b]	0.98±0.38[b]	164.21±21.13[b]	18.83±2.90[a]	0.19±0.07[a]
SEM	4.55	5.85	0.43	0.08	4.15	0.68	0.01
P-Value	0.02	<0.001	0.14	0.013	<0.001	0.215	0.987

Data are expressed as mean ± standard deviation (SD).
[a,b] Mean values with different superscripts in the same column indicate a significant difference ($p \leq 0.05$).

Table 4. Descriptive statistics and correlation analysis of egg production and blood parameters in local (Elba) and commercial (Hy-line Brown) chickens

Parameter	Mean ± SD	Range	Correlation with egg production
Egg Production (eggs)	46.29 ± 7.71	33–57	1.0000
Cholesterol (mg/dL)	109.61 ± 32.14	63.21–267.9	$r = -0.3642$, $p = 0.0015$
Triglycerides (mg/dL)	156.89 ± 68.97	51.68–290.4	$r = -0.8368$, $p < 0.0001$
HDL (mg/dL)	5.95 ± 2.93	1.437–22.05	$r = -0.2466$, $p = 0.0342$
LDL (mg/dL)	1.13 ± 0.53	0.29–4.00	$r = -0.2633$, $p = 0.0234$
Glucose (mg/dL)	176.05 ± 30.53	120.6–277.2	$r = -0.3907$, $p = 0.0006$

3.4. Egg mass (EM)

Consistent with the trends in HDP and egg weight, the daily egg mass of Elba chickens was significantly lower than that of the commercial stock (25.70 ± 4.41 g/hen vs. 53.97 ± 2.71 g/hen, p<0.01). Egg mass provides a comprehensive view of productivity by combining the rate of lay with egg size. The 52.38% lower egg mass in Elba chickens indicates a substantial production gap. In local chickens, limited metabolic partitioning toward the oviduct results in a lower overall daily egg biomass (Ahmad et al., 2019).

3.5. Daily feed intake (DFI)

The daily feed intake of Elba chickens (71.72 ± 6.35 g/hen/day) was significantly lower (p<0.01) than that of the Hy-Line Brown chickens (108.63 ± 8.69 g/hen/day). While lower feed intake reduces maintenance costs, it is insufficient to meet the high nutrient requirements of intensive laying. This lower intake is partly due to the smaller body weight at metabolic maturity in the Elba breed. However, even relative to intake, the nutritional partitioning in local breeds is less efficient for production compared to commercial strains selected to convert energy specifically into egg components (Duy et al., 2020).

3.6. Feed conversion ratio (FCR)

Regarding feed efficiency, Elba chickens showed a significantly poorer FCR of 2.86 ± 0.46 compared to the 2.02 ± 0.17 observed in the commercial chickens (p<0.01). A higher FCR value in local chickens indicates that they require more feed to produce one gram of egg mass. The high FCR in Elba chicken results from a combination of lower HDP and lower egg weight, meaning a larger proportion of daily feed intake is used for basal metabolic maintenance rather than production. Similar results have been reported for other indigenous breeds, where FCR values often exceed 2.5, whereas commercial stocks are consistently near or below 2.0 (Adrizal et al., 2011; Neijat et al., 2011).

3.7. Performance consistency (SEM)

An important finding in this study was the high degree of variation within the local stock. All performance parameters exhibited higher Standard Error of the Mean (SEM) and Standard Deviation (SD) in the Elba chickens compared to the commercial stock (e.g., FCR SD of 0.46 for Elba vs. 0.17 for Hy-Line). This high variation indicates that the Elba chicken population remains genetically diverse and unpurified for production traits. While commercial breeds exhibit extreme uniformity, local Elba chickens still show a wide range of performance levels. This variation offers an opportunity: the presence of high-performing individuals within the Elba population suggests that genetic improvement could be achieved through a structured selection program (Tadesse et al., 2013).

3.8. Blood lipid and glucose profiles

The biochemical analysis of blood plasma revealed distinct metabolic differences between the local Elba and commercial Hy-Line Brown chickens (**Table 3**). These differences reflect the physiological adaptations of the local breed and its lack of intensive selection for hyper-productive traits.

3.9. Total cholesterol and triglycerides

Elba chickens exhibited significantly higher total cholesterol levels (120.38 ± 37.41 mg/dL) compared to the commercial Hy-Line Brown stock (98.84 ± 15.21 mg/dL, p=0.02). This elevation in the local breed is consistent with observations by Dutta et al. (2013), who reported higher cholesterol levels in indigenous poultry than in improved strains. Furthermore, the triglyceride (TG) levels in Elba chickens were substantially higher, averaging 213.55 ± 47.99 mg/dL compared to 100.23 ± 23.49 mg/dL in the commercial chickens (p<0.001).

These elevated lipid concentrations in Elba chickens are linked to a different metabolic partitioning strategy. In commercial layers, high rates of egg production require a continuous, rapid transfer of lipids from the liver to the ovary for yolk formation. The significantly lower egg production observed in Elba chickens suggests that lipids, particularly triglycerides, remain in circulation longer rather than being deposited into the yolk. This is supported by the strong negative correlation between

Table 5. Correlation matrix of egg production and blood parameters in combined Elba and Hy-line brown chicken populations

Correlation matrix	Egg production	Cholesterol	Triglycerides	HDL	LDL	Glucose
Egg Production	1.0000	−0.3642	−0.8368	−0.2466	−0.2633	−0.3907
Cholesterol	−0.3642	1.0000	0.4780	0.3093	0.3248	0.1035
Triglycerides	−0.8368	0.4780	1.0000	0.1662	0.1824	0.3521
HDL	−0.2466	0.3093	0.1662	1.0000	0.9890	−0.1662
LDL	−0.2633	0.3248	0.1824	0.9890	1.0000	−0.1509

egg production and triglyceride levels (r= −0.8368, p<0.001). Indigenous chickens tend to maintain higher circulating lipid reserves and exhibit different hepatic lipid metabolism patterns, whereas commercial laying strains are genetically selected for rapid lipid mobilization toward egg yolk deposition and egg production efficiency (Ji et al., 2023).

3.10. Lipoprotein fractions (LDL and HDL)

The concentration of Low-Density Lipoprotein (LDL) was significantly higher in Elba chickens at 1.28 ± 0.61 mg/dL compared to 0.98 ± 0.38 mg/dL in the commercial group (p=0.013). High-Density Lipoprotein (HDL) levels were also slightly higher in the Elba group (6.86 ± 3.34 mg/dL vs. 5.25 ± 2.03 mg/dL), though this difference was not statistically significant (p=0.14).

The elevated LDL in Elba chickens suggests a higher rate of lipid transport to peripheral tissues. Despite the differences in absolute values, the LDL/HDL and TC/HDL ratios remained stable between the two breeds (p>0.05). This stability indicates that, while the Elba chicken has a higher baseline for lipid circulation, the proportional relationship among cholesterol fractions remains physiologically balanced, reflecting an evolutionary adaptation to maintain cardiovascular health despite higher circulating fat (Elshazly et al., 2015).

3.11. Plasma glucose levels

Glucose levels were significantly higher in the local Elba chickens (187.89 ± 30.79 mg/dL) compared to the commercial stock (164.21 ± 21.13 mg/dL, p<0.001). Higher blood glucose levels in indigenous chickens may be associated with elevated corticosterone secretion and stronger physiological responses to environmental stressors compared with highly selected commercial strains (Akinyemi and Adewole, 2021). While commercial chickens have been selected for metabolic stability under intensive housing, local breeds like the Elba retain heightened metabolic alertness, which manifests as higher plasma glucose levels.

3.12. Correlation between egg production and lipid profiles

A strong negative correlation was observed between egg production and triglyceride levels (r=−0.8368, p<0.001), demonstrating that high circulating triglycerides are associated with lower laying rates in the Elba chicken (**Table 3**). This indicates that in lower-producing local breeds, lipids are maintained in the bloodstream rather than being efficiently mobilized for yolk synthesis.

Regarding the relationship among lipid fractions, a strong positive correlation was observed between HDL and LDL levels (r=0.9890, p<0.001). This association is consistent with Tian et al. (2019), who noted that lipoprotein fractions in poultry fluctuate in tandem due to their shared hepatic metabolic pathways. The moderate positive correlation between total cholesterol and triglyceride levels (r=0.4780, p<0.05) indicates that these parameters are linked markers of overall lipid status. These results reinforce the necessity of monitoring blood lipid profiles as physiological indicators of production efficiency (Beuković et al., 2011).

4. Conclusion

This study establishes that Elba chickens currently exhibit significantly lower production efficiency, characterized by reduced hen-day production, lighter egg weights, lower daily egg mass, and a poorer feed conversion ratio compared to the commercial benchmark. Physiologically, this lower reproductive output in the Elba breed corresponds with significantly elevated circulating levels of triglycerides, total cholesterol, LDL, and blood glucose. The strong negative correlation between egg production and triglycerides indicates that the local breed is less efficient at mobilizing circulating lipids into the developing egg yolk, resulting in higher baseline blood lipid concentrations. Despite these higher absolute lipid values, the proportional lipid ratios in Elba chickens remain balanced, indicating an intact lipid transport mechanism. Importantly, the high phenotypic and metabolic variability observed within the Elba population confirms a diverse genetic base. This variation indicates that structured selective breeding programs could utilize these traits to improve the egg-laying capacity and metabolic partitioning of the Elba chicken, bridging the production gap with commercial breeds while preserving indigenous genetic resources.

5. Conflict of interest

No potential conflict of interest relevant to this article was reported. All authors have agreed with the contents of the manuscript.

6. Funding statement

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8. Author's contribution

The authors confirm their contribution to the paper as follows: study conception and design: II, SAS; data collection: II, SAS, HSW; analysis and interpretation of results: II, SAS, MYA; draft manuscript preparation: II, MYA, SAS, HSW.

9. Ethics approval

The research procedure was carried out in accordance with the regulations set by the Ethical Clearance Commission of the Institute for Research and Community Service, Jenderal Soedirman University, with ethical clearance number 01.007/KEP.SAINTEK/IV/2024.

REFERENCES

Adrizal, A., Yusrizal, Y., Fakhri, S., Haris, W., Ali, E., and Angel, R. (2011). Feeding native laying hens diets containing palm kernel meal with or without enzyme supplementation: 1. feed conversion ratio and egg production. *The Journal of Applied Poultry Research*, 20(1):40–49.

Ahmad, S., Mahmud, A., Hussain, J., and Javed, K. (2019). Productive performance, egg characteristics and hatching traits of three chicken genotypes under free-range, semi-intensive, and intensive housing systems. *Brazilian Journal of Poultry Science*, 21(2).

Akinyemi, F. and Adewole, D. (2021). Environmental stress in chickens and the potential effectiveness of dietary vitamin supplementation. *Frontiers in Animal Science*, 2:775311.

Amao, S. (2024). Egg production characteristics of nigerian indigenous chickens, rhode island red and their crossbred progenies. *Trends in Agricultural Science*, 3(1):29–37.

Beuković, D., Ljubojević, D., Beuković, M., Glamočić, D., Bjedov, S., and Stanaćev, V. (2011). Effect of antinutritional factors and extrusion at the level of cholesterol, triglycerides, total protein and testosterone in serum of broiler chickens. *Biotechnology in Animal Husbandry*, 27(4):1715–1726.

Dutta, R., Rahman, M., Rabbani, M., and Khatun, M. (2013). Haematological and biochemical profiles of indigenous, exotic and hybrid chicken breeds (gallus domesticus l.) from rajshahi, bangladesh. *Bangladesh Journal of Zoology*, 40(2):135–144.

Duy, N., Mai, H., Tien, N., Phuong, N., and Ton, V. (2020). Impact of farming models on the reproductive performance and egg quality of vietnamese local chicken breeds: Ho and dong tao. *Vietnam Journal of Agricultural Sciences*, 3(1):495–503.

El-Tahawy, W. S. and Habashy, W. S. (2021). Genetic effects on growth and egg production traits in two-way crosses of egyptian and commercial layer chickens. *South African Journal of Animal Science*, 51(3):349–354.

Elshazly, M. B., Quispe, R., Michos, E. D., Sniderman, A. D., Toth, P. P., Banach, M., Kulkarni, K. R., Coresh, J., Blumenthal, R. S., Jones, S. R., and Martin, S. S. (2015). Patient-level discordance in population percentiles of the total cholesterol to high-density lipoprotein cholesterol ratio in comparison with low-density lipoprotein cholesterol and non high-density lipoprotein cholesterol. *Circulation*, 132(8):667–676.

Falculan, K. N. (2023). Phenotypic characterization of native chicken in san andres, romblon, philippines. *Medicon Agriculture & Environmental Sciences*, 5(1):03–18.

Ji, Q., Chang, P., Dou, Y., Zhao, Y., and Chen, X. (2023). Egg yolk fat deposition is regulated by diacylglycerol and ceramide enriched by adipocytokine signaling pathway in laying hens. *Animals*, 13(4):607.

Khalil, M. (2020). Genetic evaluation for sexual maturity and egg production traits in crossbreeding experiment involving four local strains of chickens. *Annals of Agricultural Science Moshtohor*, 58(3):585–598.

Malomane, D., Simianer, H., Weigend, A., Reimer, C., Schmitt, A., and Weigend, S. (2019). The synbreed chicken diversity panel: a global resource to assess chicken diversity at high genomic resolution. *BMC Genomics*, 20:345.

Malomane, D., Weigend, S., Schmitt, A., Weigend, A., Reimer, C., and Simianer, H. (2021). Genetic diversity in global chicken breeds in relation to their genetic distances to wild populations. *Genetics Selection Evolution*, 53(1).

Neijat, M., House, J., Guenter, W., and Kebreab, E. (2011). Production performance and nitrogen flow of shaver white layers housed in enriched or conventional cage systems. *Poultry Science*, 90(3):543–554.

Nie, C., Almeida, P., Jia, Y., Bao, H., Ning, Z., and Qu, L. (2019). Genome-wide single-nucleotide polymorphism data unveil admixture of chinese indigenous chicken breeds with commercial breeds. *Genome Biology and Evolution*, 11(7):1847–1856.

Park, M. N., Choi, J. A., Lee, K.-T., Lee, H.-J., Choi, B.-H., Kim, H., Kim, T.-H., Cho, S., and Lee, T. (2013). Genome-wide association study of chicken plumage pigmentation. *Asian-Australasian Journal of Animal Sciences*, 26(11):1523–1528.

Qanbari, S., Rubin, C., Maqbool, K., Weigend, S., Weigend, A., Geibel, J., and et al. (2019). Genetics of adaptation in modern chicken. *PLoS Genetics*, 15(4):e1007989.

Rubin, C., Zody, M., Eriksson, J., Meadows, J., Sherwood, E., Webster, M., and et al. (2010). Whole-genome resequencing reveals loci under selection during chicken domestication. *Nature*, 464(7288):587–591.

Sha, Y., Gao, C., Liu, M., and Zhao, S. (2020). Evaluation of the genetic diversity of six chinese indigenous chickens. *Asian-Australasian Journal of Animal Sciences*, 33(10):1566–1572.

Tadesse, D., Singh, H., Mengistu, A., Esatu, W., and Dessie, T. (2013). Study on productive performances and egg quality traits of exotic chickens under village production system in east shewa, ethiopia. *African Journal of Agricultural Research*, 8(13):1123–1128.

Tian, W., Wang, Z., Yue, Y., Li, H., Li, Z., Han, R., and et al. (2019). Mir-34a-5p increases hepatic triglycerides and total cholesterol levels by regulating acsl1 protein expression in laying hens. *International Journal of Molecular Sciences*, 20(18):4420.

Xu, D. (2023). Whole-genome sequencing revealed genetic diversity, structure and patterns of selection in guizhou indigenous chickens. *BMC Genomics*, 24(1).