Growth-Related Hormone Profiles in Four Chicken Genotypes Under Nigerian Humid Tropical Conditions

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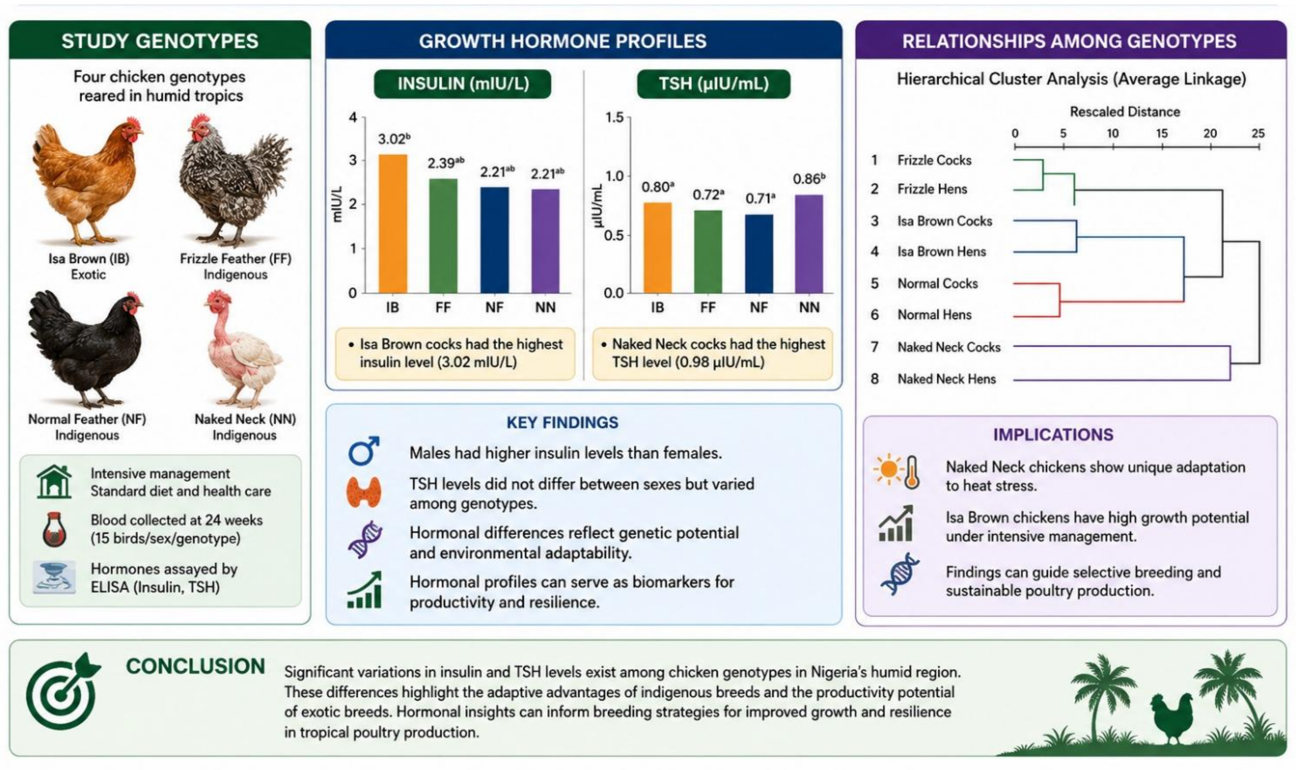

Abstract

Variability of growth-related hormones across different chicken (*Gallus gallus*) genotypes is crucial for understanding their adaptive capabilities, performance potential, and suitability for production in the humid region of Nigeria. This study investigated the diversity of growth-related hormones, specifically insulin and thyroid-stimulating hormone (TSH), among four chicken genotypes—Normal Feather (NF), Frizzle Feather (FF), Naked Neck (NN), and ISA Brown (IB)—raised in Nigeria's humid region. A total of 120 chickens, evenly distributed across genotypes and sexes, were sampled at 24 weeks of age. Hormonal levels were analyzed using the Enzyme-Linked Immunosorbent Assay (ELISA) method. Data were analyzed using the General Linear Model and Cluster Analysis of the Statistical Package for Social Sciences (Version 22), the mean difference of the different groups was determined using Two-way Analysis of Variance (ANOVA). Significance level was at $P<0.05$. Results revealed significant genotype-specific differences in hormone levels. Insulin levels were highest in IB cocks (3.02 ± 0.44) and lowest in NF hens (1.88 ± 0.06), while TSH levels peaked in NN (0.98 ± 0.09) and were lowest in FF cocks (0.64 ± 0.06). Cocks generally exhibited higher insulin levels than hens, whereas TSH levels were consistent across sexes. NN chickens demonstrated a unique hormonal profile, marked by elevated TSH levels, suggesting superior adaptability to environmental stressors. The dendrogram illustrated that FF birds share similarities with

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the IB group before clustering with the NF birds. NN birds are the most distinct group, clustering with the others only at a higher rescaled distance, indicating lower similarity compared to other groups. These findings highlight the interplay between genotype, hormonal regulation, and environmental adaptability, offering valuable insights for breeding programs aimed at enhancing poultry productivity in tropical regions.

Keywords**:** *Chickens, Hormones, Genotypes, Growth, Variability*

Introduction

The investigation of growth-related hormones across diverse chicken genotypes in Nigeria's humid region represents a significant research domain with substantial implications for poultry production, food security, employment, and economic growth. Chickens serve as a primary protein source for numerous communities in Nigeria, and elucidating the hormonal mechanisms that govern growth can facilitate the development of enhanced breeding strategies and management practices. Among the numerous factors that impact poultry productivity, growth performance serves as a critical determinant, directly influencing meat yield, market value, and overall profitability. The growth of chickens is governed by intricate interactions among genetic, environmental, and physiological factors, with growth-related hormones playing a pivotal role in mediating these processes (Akintunde et al., 2021). An examination of the variability of growth-related hormones across different chicken genotypes is crucial for understanding their adaptive capabilities, performance potential, and suitability for production in specific ecological zones, such as the humid region of Nigeria.

The humid region of Nigeria is characterized by high temperatures, substantial rainfall, and elevated humidity levels, which present significant challenges to poultry production. These environmental stressors affect growth, metabolism, and hormonal regulation in chickens, with variations that may be genotype-dependent (Oke et al., 2021; Ademola et al., 2020, 2023). Local chicken breeds, typically raised in extensive systems, demonstrate traits such as disease resistance and adaptability to harsh environments; however, they generally exhibit lower growth rates and productivity compared to exotic breeds. In contrast, exotic breeds, which are primarily selected for high growth and production efficiency under controlled conditions, often face difficulties in adapting to tropical climates. Consequently, investigating the diversity of growth-related hormones among these genotypes offers valuable insights into their physiological responses and potential for sustainable production in the humid tropics (Lamido et al., 2025).

The poultry sector in Nigeria is characterized by a rich array of chicken genotypes, encompassing both indigenous breeds and exotic strains (Adeleke et al., 2011). Indigenous chickens, often referred to as local or village chickens, are well adapted to the tropical climate, demonstrating resilience to diseases and the ability to thrive on limited resources (Wheto et al., 2022; Mkpughe and Bratte, 2015). However, these local breeds generally exhibit lower growth rates and production traits in comparison to their exotic counterparts, which have been selectively bred for superior performance (Amao et al., 2024). The observed differences in growth performance among these genotypes can be attributed to a multitude of factors, including genetic variations, environmental adaptability, and hormonal regulation as there are interactions among these attributes especially for Nigerian-local chickens and Isa Brown chickens (Akintunde, 2018; Akintunde et al., 2020, Akintunde and Toye, 2021).

Growth-related hormones, such as growth hormone (GH), Thyroid-Stimulating Hormone (TSH), Triiodothyronine (T3), Thyroxine (T4), insulin-like growth factor 1 (IGF-1), and ghrelin, are critical in regulating growth and metabolism in chickens. GH, synthesized by the pituitary gland, stimulates growth by promoting protein synthesis and influencing metabolic processes (Alfano et al., 2023; Wheto et al., 2020). Thyroid-Stimulating Hormone (TSH), Triiodothyronine (T3), and Thyroxine (T4) are integral to the growth and development of chickens, significantly impacting

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metabolic processes and overall physiological health. TSH is synthesized by the anterior pituitary gland and serves to stimulate the thyroid gland to produce and release T3 and T4. The regulation of TSH levels is mediated by the hypothalamus through the secretion of thyrotropin-releasing hormone (TRH), thereby establishing a feedback mechanism that is crucial for maintaining hormonal equilibrium (Zhang et al., 2022). In avian species, sufficient levels of TSH are essential for optimal thyroid function, which is vital for growth. IGF-1, primarily produced in the liver in response to GH, mediates many of GH's effects and is essential for muscle development and overall growth (Xiao et al., 2017; Okafor et al., 2019).

The interaction of indigenous chicken genotypes: Normal Feather, Frizzle Feather, and Naked Neck with the exotic ISA Brown breed in Nigeria's humid region underscores the role of genetic diversity and hormonal regulation in poultry adaptation and productivity. Normal Feather chickens exhibit strong disease resistance and adaptability but have slower growth rates due to lower nucleotide diversity in growth-related genes (Wheto et al., 2022). Frizzle Feather chickens are better adapted to heat with higher levels of growth hormones (GH and IGF-1), supporting better growth performance than other indigenous breeds (Zhu La et al., 2023; Sun et al., 2024). Naked Neck chickens thrive in harsh climates due to heat tolerance but face challenges in fertility and growth linked to lower hormonal levels (Wheto et al., 2020). Exotic ISA Brown Chickens are optimized for rapid growth and high egg production in controlled environments, benefiting from elevated levels of growth hormones. However, they struggle to adapt to the humid tropics compared to indigenous breeds (Antar et al., 2020).

Analyzing the levels and variations of these hormones among different chicken genotypes can yield valuable insights into their growth potential and adaptability. The diversity of growth-related hormones among chicken genotypes is crucial for comprehending their growth performance and metabolic efficiency. In the context of Nigeria, the exploration of growth-related hormones across various chicken genotypes is particularly pertinent due to the nation's dependence on poultry for protein and economic sustenance. The humid climate poses unique challenges for poultry production, underscoring the necessity for a comprehensive understanding of how local breeds can be optimized for growth through hormonal regulation. This study seeks to investigate the hormonal profiles associated with various genotypes in order to identify potential genetic markers that may be utilized in breeding programs aimed at improving growth performance in indigenous chicken populations.

Materials and Methods

Study Location

The research was carried out at Babcock University, Ilishan-Remo, Ogun State, Nigeria and the Federal University of Agriculture, Abeokuta, Nigeria. These institutions are representatives of Nigeria's humid region, which is characterized by elevated temperatures, substantial rainfall, and high humidity levels. The experimental framework was established within a controlled poultry research facility specifically designed to replicate the natural environmental conditions of the region, thereby ensuring consistency in the data collection process.

Experimental Design

Three genotypes of Nigerian indigenous chickens - Normal Feather (NF), Frizzle Feather (FF), and Naked Neck (NN) and one genotype of the exotic breed , ISA Brown (IB) were used for the study.

Management of Experimental Birds

All chickens were reared in intensive systems without access to outdoor runs. The birds were provided with a standard commercial poultry diet specifically formulated to fulfill their nutritional needs for growth. Clean drinking water was made available *ad libitum*. Standardized vaccination protocols and health management practices were implemented to reduce the risk of disease.

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Sampling Procedures
Blood Collection

Blood samples were obtained from the wing vein of chickens at 24 weeks of age. Blood samples were collected from 15 birds per sex per genotype. Each sample, approximately 3 mL in volume, was collected using sterile syringes and subsequently transferred into heparinized tubes for hormone analysis, as well as into plain tubes for serum separation. The serum samples were preserved at -20 °C until further analysis.

Hormonal Analysis

The Enzyme-linked immunosorbent assay (ELISA) technique was used to assay for serum Insulin and Thyroid Stimulating Hormone (TSH) using Calbiotech kits (El Cajon, California). The procedures for the assays were carried out according to the kits' manual.

Statistical Analysis

Data were expressed as mean ±S.E.M and analyzed using the General Linear Model and Cluster Analysis of the Statistical Package for Social Sciences (Version 22). The mean difference of the different groups was determined using Two-way Analysis of Variance (ANOVA). Significance level was at $P<0.05$.

Data used for hierarchical cluster analysis were analyzed by descriptive statistics after which they were subjected to hierarchical cluster analysis using average linkage with SPSS (version 22) statistical package to produce dendogram which indicates the relationship among the 4 genetic groups.

Results

Table 1 shows the mean values and standard error of means of insulin and thyroid-stimulating hormone (TSH) levels across the four genotypes of chickens. The main findings are as follows:

Insulin Levels: Isa Brown Cocks (IBM) had significantly highest ($p<0.05$) insulin level (3.02 ± 0.44 mIU/L), while Normal Feathered Hens (NFF) recorded significantly lowest ($p<0.05$) values (1.88 ± 0.06 mIU/L). Significant differences ($p<0.05$) were observed between IBM and NFF, with intermediate values for the other genotypes, including Frizzled Feather Males and Females (FFM and FFF) and Naked Necked Males and Females (NNM and NNF).

TSH Levels: Naked Necked Cocks (NNM) had significantly highest ($p<0.05$) TSH levels (0.98 ± 0.09 µIU/mL), significantly higher than most other genotypes, while Frizzled Feathered Males (FFM) recorded the lowest (0.64 ± 0.06 µIU/mL). The TSH levels among hens (FFF, IBF, NFF, and NNF) were generally consistent, with moderate variability.
Table 2 summarizes the fixed effects of sex and genotype on insulin and TSH levels and their interactions:

Insulin: Insulin levels were higher in cocks (2.57 ± 0.15 mIU/L) compared to hens (2.14 ± 0.07 mIU/L), with no statistically significant interaction between sex and genotype ($p > 0.05$). Among genotypes, Isa Browns (IB) showed the highest insulin levels (2.54 ± 0.21 mIU/L), while Normal Feathered (NF) and Naked Necked (NN) genotypes showed similar levels (2.21 ± 0.26 and 2.21 ± 0.08 mIU/L, respectively).

TSH: The TSH levels were consistent across sexes, with no significant differences between males (0.77 ± 0.05 µIU/mL) and females (0.77 ± 0.03 µIU/mL). Among genotypes, Naked Necked chickens (NN) exhibited the highest TSH levels (0.86 ± 0.08 µIU/mL), suggesting a unique hormonal profile for this group.

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Table 1: Main Effect of Growth Hormones in Four Genotypes of Chickens

	FF M	FF F	IB M	IB F	NF M	NF F	NN M	NN F
Insulin (mIU/L)	2.51 ±0.08[ab]	2.27 ±0.12[ab]	3.02 ±0.44[b]	2.30 ±0.13[ab]	2.53 ±0.47[ab]	1.88 ±0.06[a]	2.37 ±0.07[ab]	2.05 ±0.04[a]
TSH (μIU/m)	0.64 ±0.06[a]	0.80 ±0.07[ab]	0.79 ±0.02[a]	0.81 ±0.05[ab]	0.69 ±0.05[a]	0.73 ±0.08[a]	0.98 ±0.09[b]	0.73 ±0.06[a]

Frizzled Feather Cocks – FFM, Frizzled Feather Hens – FFF, Isa Brown Cocks – IBM, Isa Brown Hens – IBF, Normal Feathered Cocks –NFM, Normal Feathered Hens – NFF, Naked Necked Cocks – NNM, Naked Necked Hens-NNF, TSH – Thyroid Stimulating Hormone
Values are presented as mean ± standard error of mean, a,b: Means within the same row with different superscripts are significantly different ($P < 0.05$)

Table 2: Fixed Effects and Interaction Effect of Growth Hormones in Four Genotypes of Chickens

	ALL M	ALL F	FF	IB	NF	NN	Interaction
Insulin (mIU/L)	2.57 ± 0.15	2.14 ± 0.07	2.39 ± 0.09	2.54 ± 0.21	2.21 ± 0.26	2.21 ± 0.08	0.11
TSH (μIU/mL)	0.77 ± 0.05	0.77 ± 0.03	0.72 ± 0.06	0.80 ± 0.03	0.71 ± 0.04	0.86 ± 0.08	0.09

Frizzled Feather – FF, Isa Brown – IB, Normal Feather – NF, Naked Neck – NN, Cocks – ALL M, Hens – ALL F, TSH – Thyroid Stimulating Hormone
Values are presented as mean ± standard error of mean, [a,b]: Means within the same row with different superscripts are significantly different ($P < 0.05$)

The dendrogram as presented in Figure 1, generated using hierarchical clustering and the average linkage method, shows the relationships between the experimental groups: Frizzled Feather Cocks (1), Frizzled Feather Hens (2), Isa Brown Cocks (3), Isa Brown Hens (4), Normal Feathered Cocks (5), Normal Feathered Hens (6), Naked Necked Cocks (7), and Naked Necked Hens (8). The clustering results reveal the following key findings: Frizzled Feather Cocks (1) and Frizzled Feather Hens (2) form the first cluster, indicating high similarity in traits or characteristics measured. Isa Brown Cocks (3) and Isa Brown Hens (4) also cluster closely together, forming a distinct subgroup. Normal Feathered Cocks (5) and Normal Feathered Hens (6) display close association, forming another cluster. Naked Necked Cocks (7) and Naked Necked Hens (8) are grouped into a final distinct cluster.

The dendrogram as presented in Figure 1 illustrates that Frizzled Feather birds (1 and 2) share similarities with the Isa Brown group (3 and 4) before clustering with the Normal Feathered birds (5 and 6). Naked Necked birds (7 and 8) are the most distinct group, clustering with the others only at a higher rescaled distance, indicating lower similarity compared to other groups.

Discussion

The results indicate significant variations in insulin and TSH levels among the four genotypes of chickens, highlighting genotype and sex as key factors influencing these growth hormones. Isa Brown Cocks (IBM) demonstrated the highest insulin levels, which could be linked to their genetic predisposition for efficient metabolism and growth. Insulin plays a crucial role in regulating glucose uptake and overall growth performance (Foote et al., 2024). The lower insulin levels observed in Normal Feathered Hens (NFF) may imply reduced metabolic efficiency or slower growth rates, aligning with previous findings that hens generally exhibit lower growth rate which could partly be due to lower insulin sensitivity compared to cocks (Adebambo et al., 2020).

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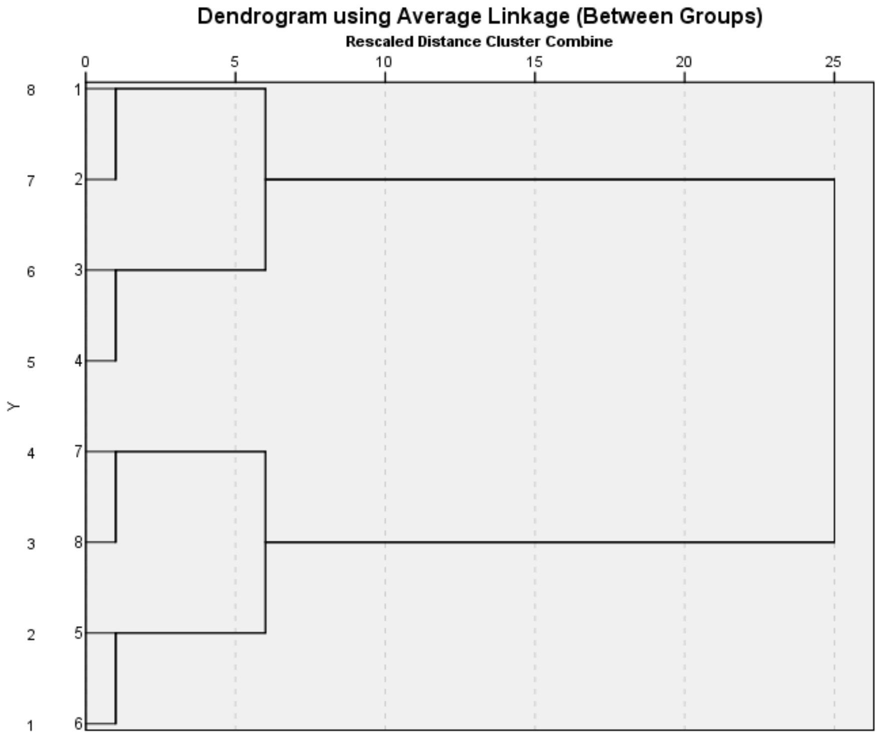

Figure 1: Dendogram for Growth Hormones obtained from average linkage (between groups) Hierarchical agglomerative clustering among four chicken strains. 1 - Frizzled Feather Cocks, 2 - Frizzled Feather Hens, 3 - Isa Brown Cocks, 4 - Isa Brown Hens, 5 - Normal Feathered Cocks, 6 - Normal Feathered Hens, 7 - Naked Necked Cocks, 8 - Naked Necked Hens

The elevated TSH levels in NN Cocks are consistent with their adaptive physiology for heat tolerance. Thyroid hormones are necessary for the normal functioning of physiological systems. Therefore, knowledge of any factor (whether genetic, environmental or intrinsic) that alters the levels of thyroid-stimulating hormone (TSH) and thyroid hormones is crucial. Genetic factors contribute up to 65% of interindividual variations in TSH and thyroid hormone levels, but many environmental factors can also affect thyroid function (Babić Leko et al., 2021). TSH is associated with metabolic and thermoregulatory processes, and its higher concentration could reflect the enhanced thyroid activity needed for maintaining homeostasis in tropical environments (Iwen et al., 2018). Thyroid hormones play crucial roles in energy metabolism, temperature regulation, and overall growth (Sung and Kim, 2024). They are delicately regulated through the feedback mechanism of the hypothalamus-pituitary-thyroid axis to maintain metabolic homeostasis in the body (Mullur et al., 2014). In healthy individuals, TSH and thyroid hormone levels are primarily influenced by genetic factors (Sung and Kim, 2024). Conversely, the lower TSH levels in Frizzled Feathered Males (FFM) may suggest reduced thyroid gland activity, potentially linked to their unique feather morphology, which impacts thermoregulation.

Males generally exhibited higher insulin levels than females across all genotypes. This finding aligns with prior studies showing that male chickens tend to have greater energy demands for muscle development, which is mediated by insulin (Saleh et al., 2018). However, TSH levels showed no significant sex differences, indicating that thyroid activity may be more genotype-specific than sex-dependent.

The distinct hormonal profiles among genotypes suggest opportunities for targeted breeding programs. For instance, Isa Browns, with their higher insulin levels, could be prioritized for improved growth performance, while Naked Necked chickens may be ideal for environments requiring heat tolerance. Hormonal profiles can serve as biomarkers for metabolic health and productivity.

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Monitoring insulin and TSH levels could help identify and mitigate growth or health challenges in poultry farming. The high TSH levels in Naked Necked chickens underscore their suitability for tropical and heat-stressed environments. These findings could inform strategies to optimize poultry production in regions affected by climate change.

The close clustering of Frizzled Feather (1 and 2) and Isa Brown (3 and 4) groups may reflect shared traits such as feather structure or metabolic similarities. Studies have shown that feather types can influence thermoregulation and energy metabolism in poultry (Mota-Rojas et al., 2021). These shared traits could explain their proximity in the clustering analysis. Naked Necked birds (7 and 8) forming a separate cluster suggests unique physiological or genetic traits that differentiate them from the other groups. Naked Necked birds are known for their increased heat tolerance and adaptation to tropical climates, which may lead to distinct metabolic or phenotypic profiles (Meteyake et al., 2023). Normal Feathered birds (5 and 6) form an intermediate cluster, reflecting characteristics that overlap with both the Frizzled Feather and Isa Brown groups but remain distinct enough to form their cluster. This could indicate a balance of traits between heat tolerance and productivity.

The observed clustering patterns could guide selective breeding programs aimed at improving specific traits such as heat tolerance, productivity, or resilience. The distinct traits of Naked Necked birds could be harnessed for breeding poultry adapted to high-temperature environments. Understanding these relationships can aid in tailoring diets, housing conditions, and management practices to maximize the genetic potential and well-being of different poultry breeds.

Conclusions

This study underscores the significant diversity in growth-related hormones among chicken genotypes raised in Nigeria's humid region, revealing the intricate relationship between genotype, hormonal regulation, and environmental adaptability. ISA Brown chickens exhibited the highest insulin levels, reflecting their genetic predisposition for rapid growth and productivity. Conversely, Naked Neck chickens demonstrated elevated TSH levels, indicating potential resilience to environmental stressors. These hormonal variations emphasize the adaptive advantages of indigenous breeds in tropical climates and the productivity potential of exotic breeds under controlled conditions. The insights provided by this study can inform targeted breeding strategies, promoting sustainable poultry production in regions with challenging climatic conditions.

Conflict of Interest

Authors declare no conflict of interests and have no financial or personal relationship(s) which may have inappropriately influenced the research and write-up of this paper.

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