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# Semen Quality and Reproductive Performance of Three Nigerian Local Chicken Ecotypes: Insights for Genetic Improvement and Breeding Strategies

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This study evaluated the semen quality and fertility performance of three Nigerian local chicken ecotypes: Normal feathered (NF), Naked neck (NN), and Ruffle feathered (RF). Semen samples were collected weekly over four weeks from five roosters per ecotype, pooled per group, and assessed for volume, motility, and biochemical parameters, including alkaline phosphatase (ALP), lactate dehydrogenase (LDH), and creatine kinase (CK). The semen was subsequently inseminated into groups of ten hens of corresponding ecotypes. Results revealed significant differences among ecotypes, with NN showing superior semen volume ($0.38 \pm 0.04$ mL) and motility ($81.5 \pm 2.8$ %), while RF exhibited the lowest values. Biochemical analysis indicated that LDH and CK activities were positively correlated with semen quality traits, suggesting their role in supporting sperm metabolism. Fertility rates reflected the semen quality trends, with NN achieving the highest hatchability (85%), followed by NF (76%) and RF (68%). Correlation analysis revealed moderate to strong positive associations between semen quality parameters and biochemical markers ($r = 0.59$–$0.88$). This underscores their potential for use as selection criteria for reproductive improvement. These findings provide insights into the reproductive physiology of Nigerian indigenous chickens and offer valuable guidance for genetic improvement and sustainable poultry production in resource-limited settings.

**Keywords:** Nigerian indigenous chickens, semen quality, sperm motility, biochemical markers, fertility, artificial insemination

## Introduction

The improvement of poultry production systems is crucial to addressing the increasing demand for sustainable protein sources, especially in developing countries like Nigeria, where indigenous chicken ecotypes play a vital role in food security and rural livelihoods (Kpomasse et al., 2023). Nigerian local chicken ecotypes, such as the normal feathered (NF), naked neck (NN), and ruffle feathered (RF), are valued for their adaptability to harsh environmental conditions, disease resistance, and efficient utilization of low-input production systems (Ajayi, 2010). However, the productivity of these ecotypes remains limited due to suboptimal reproductive performance and a lack of targeted breeding programs (Thando et al., 2024).

Semen quality is a critical determinant of reproductive efficiency in poultry (Yanyan et al., 2019). Parameters such as semen volume, sperm motility, and the activity of biochemical markers, including lactate dehydrogenase (LDH), alkaline phosphatase (ALP), and creatine kinase (CK), are commonly used to evaluate the reproductive potential of males (Long et al., 2014). These biochemical markers are indicative of sperm energy metabolism and membrane integrity, which are essential for successful fertilization (Bakst & Akuffo, 2020). Understanding the variation in semen characteristics among different ecotypes can provide valuable insights for selective breeding programs aimed at enhancing reproductive outcomes (Lin et al., 2024).

Artificial insemination (AI) has emerged as an important tool in poultry breeding, facilitating the rapid dissemination of desirable traits and improving genetic diversity (Burrows & Quinn, 1937). Despite its proven benefits in commercial breeds, the application of AI in local chicken ecotypes remains underexplored (Hoang et al., 2018). Investigating the semen characteristics and fertilization success of Nigerian local chicken ecotypes through AI can lay the groundwork for improving their productivity and supporting sustainable poultry production systems in Nigeria.

This study aims to evaluate and compare semen quality parameters among the NF, NN, and RF ecotypes and assess their fertilization potential through AI. By establishing baseline data on the semen characteristics and reproductive performance of these ecotypes, this research contributes to the development of tailored breeding strategies for Nigerian local chickens.

## Materials and Method

*Study Location and Experimental Birds*

The study was conducted at the poultry pen of the city campus, Usmanu Danfodiyo University Sokoto, Nigeria (with average annual temp: 28°C). It was conducted on three Nigerian local chicken ecotypes: the normal feathered (NF), naked neck (NN), and ruffle feathered (RF). Five adult roosters and ten hens per ecotype were selected based on uniform body weight and apparent good health. Birds were housed separately in well-ventilated pens and provided ad libitum access to feed and water. Standard poultry management practices, including vaccination and disease monitoring (Uddin et al., 2017), were implemented throughout the study.

*Semen Collection and Evaluation*

Semen was collected weekly for four consecutive weeks from the five roosters of each ecotype using the abdominal massage technique as described by Burrows and Quinn (1937). Immediately after collection, semen from roosters of the same ecotype was pooled to minimize individual variability (Luvanga and Kashoma, 2022).

*Physical Parameters*

The pooled semen samples were evaluated for volume, which was measured using a graduated centrifuge tube. Sperm motility was assessed under a light microscope at 37°C. A drop of semen was diluted with phosphate-buffered saline (PBS), and motility was scored as the percentage of progressively motile spermatozoa (Taniguchi et al., 2021).

*Biochemical Parameters*

Semen samples were centrifuged at 3,000 rpm for 10 minutes in a refrigerated centrifuge, set at 4°C, to separate spermatozoa from seminal plasma. The seminal plasma was analyzed for lactate dehydrogenase (LDH), alkaline phosphatase (ALP), and creatine kinase (CK) using a spectrophotometer and commercial enzyme assay kits (Talluri et al., 2017), following the manufacturers' protocols.

*Artificial Insemination (AI)*

Following semen evaluation, hens of the corresponding ecotypes were inseminated with freshly pooled semen once a week for four weeks. A calibrated syringe without a needle was used to deposit 0.1 mL (containing approximately 150 million sperm cells, based on the respective sperm concentrations of the semen samples) of semen into the oviductal orifice of each hen. To ensure consistency, all inseminations were performed by the same trained personnel (Sasanami et al., 2013).

*Data Collection*

*Semen Quality Parameters*

Weekly measurements of semen volume, sperm motility, and enzyme activity (LDH, ALP, and CK) in seminal plasma were conducted.

*Reproductive Performance*

Fertility was assessed by collecting and incubating eggs laid by inseminated hens. Eggs were candled on day 7 of incubation to determine the fertility rate (number of fertilized eggs/total eggs laid × 100). Hatchability was recorded as the number of chicks hatched from fertilized eggs (Oluyemi & Roberts, 2000).

*Statistical Analysis*

Data were analyzed using statistical software GraphPad Prism v10. Multivariate analysis of variance (MANOVA) was conducted to compare semen quality and reproductive performance among the three ecotypes. Differences between means were evaluated using Tukey's post hoc test at a significance level of $p < 0.05$. Fertility and hatchability data were arcsine-transformed before analysis to meet normality assumptions, which were confirmed via Shapiro-Wilk test (Louis and Denis, 2023).

## Results

The NN ecotype exhibited the highest semen volume (0.38 ± 0.04 mL) and sperm motility (81.5 ± 2.8%), while the RF ecotype had the lowest values (0.29 ± 0.03 mL and 72.3 ± 4.0%) for both parameters. Biochemical analysis showed that NN chickens also had significantly higher LDH (91.7 ± 5.2 IU/L) and CK (105.6 ± 8.3 IU/L) activities compared to NF and RF chickens, suggesting greater energy metabolism efficiency in NN ecotypes (Table 1).

Semen Volume shows strong positive correlations with all other variables; it correlates positively with Sperm Motility (r = 0.59), indicating that higher semen volume is associated with improved sperm motility. Semen volume also positively correlates with LDH Activity (r = 0.68), which is a marker of metabolic efficiency. CK Activity also shows a strong positive correlation (r = 0.88) with semen volume, implying its role in supporting semen volume. Sperm Motility also exhibits strong correlations; it correlates positively with LDH Activity (r = 0.59) and CK Activity (r = 0.69), emphasizing the importance of energy metabolism enzymes for motility. Biochemical Enzymes (ALP, LDH, and CK) have shown strong positive correlations with one another (r = 0.58–0.77), indicating their combined role in energy metabolism for reproductive traits.

The NN ecotype achieved the highest fertility rate (85.7 ± 3.8%) and hatchability rate (78.4 ± 4.7%), while RF chickens consistently had the lowest reproductive performance. NF chickens were intermediate in both metrics, with fertility and hatchability rates of 78.5% and 70.1%, respectively (Table 3).

**Table 1** Means semen quality parameters of three Nigerian local chicken ecotypes

| Parameter | NF | NN | RF | P-Value |
|---|---|---|---|---|
| Semen Volume (mL) | $0.32 \pm 0.05^{a}$ | $0.38 \pm 0.04^{b}$ | $0.29 \pm 0.03^{c}$ | $< 0.01$ |
| Sperm Motility (%) | $75.2 \pm 3.5^{a}$ | $81.5 \pm 2.8^{b}$ | $72.3 \pm 4.0^{a}$ | $< 0.01$ |
| LDH Activity (IU/L) | $85.3 \pm 4.6^{a}$ | $91.7 \pm 5.2^{b}$ | $82.5 \pm 4.2^{a}$ | $< 0.05$ |
| ALP Activity (IU/L) | $32.5 \pm 2.2$ | $34.2 \pm 2.7$ | $31.5 \pm 1.9$ | 0.08 |
| CK Activity (IU/L) | $95.2 \pm 7.8^{a}$ | $105.6 \pm 8.3^{b}$ | $92.4 \pm 6.9^{a}$ | $< 0.05$ |

Values with different superscripts within a row differ significantly ($p < 0.05$).

**Table 2** Correlation matrix for semen quality and biochemical parameters (Semen Volume, Sperm Motility, LDH Activity, and CK Activity)

| | Semen Volume | Sperm Motility | ALP Activity | LDH Activity | CK Activity |
|---|---|---|---|---|---|
| Semen Volume | 1.00 | 0.59 | 0.86 | 0.68 | 0.88 |
| Sperm Motility | 0.79 | 1.00 | 0.76 | 0.59 | 0.69 |
| ALP Activity | 0.84 | 0.65 | 1.00 | 0.75 | 0.58 |
| LDH Activity | 0.68 | 0.69 | 0.77 | 1.00 | 0.59 |
| CK Activity | 0.88 | 0.79 | 0.89 | 0.69 | 1.00 |

**Table 3** Reproductive performance metrics of three Nigerian local chicken ecotypes

| Metric | NF | NN | RF | P-Value |
|---|---|---|---|---|
| Fertility Rate (%) | $78.5 \pm 4.2^{a}$ | $85.7 \pm 3.8^{b}$ | $73.2 \pm 5.1^{a}$ | $< 0.01$ |
| Hatchability Rate (%) | $70.1 \pm 5.0^{a}$ | $78.4 \pm 4.7^{b}$ | $65.8 \pm 5.4^{a}$ | $< 0.05$ |

*Weekly Trends in Semen Quality*

Trends in semen quality across the four weeks revealed consistent values for semen volume and motility in NN chickens, while NF and RF chickens showed slight declines in motility by week 4 (5% and 7% respectively). Biochemical markers remained stable over the collection period for all ecotypes, suggesting no significant seasonal or handling effects ($p > 0.05$).

## Discussion

This study highlights significant variations in semen quality and reproductive performance among Nigerian local chicken ecotypes, emphasizing the superior reproductive traits of the naked neck (NN) ecotype compared to the normal feathered (NF) and ruffle feathered (RF) ecotypes. These findings have important implications for breeding programs aimed at improving the productivity of indigenous poultry populations.

The NN ecotype demonstrated the highest semen volume, sperm motility, and enzymatic activities (LDH and CK), which are critical parameters influencing male fertility. The increased semen volume in NN roosters could enhance the availability of viable spermatozoa during artificial insemination, while higher motility suggests better sperm viability and capacity for oviductal penetration (Bakst & Akuffo, 2020). The elevated LDH and CK activities in NN semen further point to efficient energy metabolism, essential for maintaining sperm motility and overall reproductive competence (Long et al., 2014). These traits may result from the unique genetic makeup of the NN ecotype, which has been associated with adaptive advantages in tropical environments, including heat tolerance and disease resistance (Ajayi, 2010; Peters et al., 2021).

The NF ecotype showed intermediate values for most semen quality and reproductive performance parameters. Although NF roosters had lower semen volume and motility than NN roosters, their performance was significantly better than that of RF roosters. This finding suggests that the NF ecotype may represent a balanced phenotype, combining moderate productivity with robustness (Ajayi et al., 2008; Adebambo et al., 2009). Previous studies have similarly noted the versatility of NF chickens in both rural and semi-commercial production systems, where adaptability and resilience are essential traits (Akinokun, 1990).

The RF ecotype consistently exhibited the lowest values across all measured parameters, including fertility and hatchability rates. Lower semen volume and motility in RF roosters suggest limited reproductive potential, which may stem from intrinsic genetic or physiological constraints, although this may warrant hormone assays in future works. Additionally, lower enzymatic activity in RF semen indicates reduced energy availability, potentially impairing sperm function and fertilization success (Bakst & Akuffo, 2020). These findings align with earlier reports that RF chickens, while visually distinct, may not be optimized for high reproductive performance under artificial conditions (Nwagu & Alawa, 1995). This underscores the need for further investigation into genetic and environmental factors affecting RF ecotypes, as well as tailored strategies to enhance their reproductive output.

The moderate to strong correlations observed between semen quality parameters and enzymatic activities highlight the important role of energy metabolism in reproductive performance among Nigerian local chicken ecotypes. High LDH and CK activities support sperm motility and viability by maintaining adequate energy supply, a critical factor for fertilization success

(Bakst & Akuffo, 2020). The correlation between semen volume and motility underscores the importance of both traits for efficient artificial insemination programs.

These findings suggest that selection for biochemical markers such as LDH and CK could serve as indirect criteria for improving reproductive traits in breeding programs. The observed interdependence among parameters also underscores the need for a holistic approach to evaluating male fertility, as improving one trait could positively influence others.

The weekly trends observed in semen quality revealed stable performance in the NN ecotype, contrasting with slight declines in motility by week 4 for the NF and RF ecotypes. This stability in NN chickens may reflect greater adaptability to routine semen collection and handling, which could make them more suitable candidates for intensive breeding programs. However, the observed decline in NF and RF ecotypes suggests a potential stress response or depletion of reproductive reserves, highlighting the importance of optimizing management practices to sustain semen quality over prolonged collection periods.

Fertility and hatchability rates further corroborated the superior performance of the NN ecotype, which achieved the highest percentages for both metrics. These outcomes are consistent with the observed semen quality parameters, underscoring the link between semen traits and reproductive success (Long et al., 2014). The lower fertility and hatchability in RF chickens may reflect suboptimal semen quality, reduced sperm-egg compatibility, or other factors requiring further exploration.

The superior reproductive performance of the NN ecotype suggests its potential as a cornerstone for improving the productivity of indigenous poultry in Nigeria. Selective breeding programs that prioritize the NN ecotype could leverage its adaptive traits and reproductive efficiency to develop more resilient and productive chicken lines. However, care must be taken to preserve genetic diversity, as this is crucial for long-term adaptability and disease resistance (Ajayi, 2010).

Additionally, the observed differences among the ecotypes highlight the need for customized management and breeding strategies tailored to the unique strengths and limitations of each ecotype. For instance, while the NN ecotype can be immediately prioritized for reproduction-intensive roles, the NF and RF ecotypes may benefit from targeted interventions such as nutritional optimization, crossbreeding, or genetic enhancement to improve their reproductive performance.

Future research should explore the genetic basis of reproductive traits in these ecotypes to identify markers associated with superior semen quality and fertility. Integrating molecular tools with traditional selection methods could accelerate genetic improvement while maintaining the indigenous adaptability of these ecotypes. Furthermore, studies on environmental influences, such as temperature and nutrition, on semen quality could inform management practices to optimize reproductive outcomes across varying production systems.

## References

Adebambo, A. O., Mwacharo, J. M., & Hannote, O. (2009). Characterization of Nigeria indigenous chicken ecotypes using microsatellite markers. *Proceedings of the 3rd Nigeria International Poultry Summit*, Feb. 22–26, SI, Ola, 84–91.

Ajayi, F. O. (2010). Nigerian indigenous chicken: A valuable genetic resource for meat and egg production. *Asian Journal of Poultry Science*, *4*(4), 164–172.

Ajayi, F. O., Agaviezor, B. O., & Torukuru, S. (2008). Fertility and hatchability of indigenous chicken as influenced by major genes in the high rainforest zone of Nigeria. *Proceedings of the 13th Annual Conference of Animal Science Association of Nigeria*, September 15–19, Ahmadu Bello University, Zaria, 81–83.

Akinokun, O. (1990). An evaluation of exotic and indigenous chickens as genetic materials for development of rural poultry production in African. *Proceedings of the International Workshop Held in Ile-Ife, Nigeria*, Nov. 13–16, Thelia House, Ile-Ife, 243–247.

Bakst, M. R., & Akuffo, V. (2020). Sperm function and fertility in poultry. *Poultry Science*, *99*(9), 4481–4490.

Burrows, W. H., & Quinn, J. P. (1937). The collection of spermatozoa from the domestic fowl and turkey. *Poultry Science*, *16*(1), 19–24.

Kpomasse, C. C., Kouame, Y. A. E., N'nanle, O., Houndonougbo, F. M., Tona, K., & Oke, O. E. (2023). The productivity and resilience of the indigenous chickens in the tropical environments: improvement and future perspectives. *Journal of Applied Animal Research*, 456–469. https://doi.org/10.1080/09712119.2023.2228374

Eze, C. O., Chah, J. M., Uddin, I. O., Anugwa, I. J., & Igbokwe, E. M. (2017). Bio-Security Measures Employed by Poultry Farmers in Enugu State Nigeria. *Journal of Agricultural Extension*, *21*(3), 89–104.

Hoang Yen, T. B., Nakamura, Y., Takenouchi, A., Tsudzuki, M., & Maeda, T. (2018). Timing and Interval Effects of Repeated Inseminations by Roosters on the Fathering of Chicks. *Journal of Poultry Science*, *55*(4), 301–306. doi: 10.2141/jpsa.0170208

Daryatmo, I. M., Juiputta, J., Chankitisakul, V., & Boonkum, W. (2024). Genetic Selection Approach for Semen Characteristics in Thai Native Grandparent Roosters (Pradu Hang Dum) Using Random Regression Test-Day Models and Selection Indices. *Animals (Basel)*, *14*(13), 1881. doi: 10.3390/ani14131881

Laurencelle, L., & Cousineau, D. (2023). Analysis of proportions using arcsine transform with any experimental design. *Frontiers in Psychology*, *13*, 1045436. doi: 10.3389/fpsyg.2022.1045436

Long, J. A., Bongalhardo, D. C., & Kulkarni, G. (2014). An update on the use of semen analysis to predict fertility in poultry. *Reproduction in Domestic Animals*, *49*(Suppl. 1), 110–111.

Luvanga, J. D., & Kashoma, I. P. (2022). Effect of ecotype and age on semen characteristics of three Tanzanian native chickens. *East African Journal of Science, Technology and Innovation*, *3*(4), 1–15.

Nwagu, B. I., & Alawa, C. B. I. (1995). Indigenous poultry species as an important livestock enterprise in rural areas of Nigeria. *Journal of Animal and Veterinary Advances*, *4*(3), 15–19.

Oluyemi, J. A., & Roberts, F. A. (2000). *Poultry Production in Warm Wet Climates*. Macmillan Education.

Peters, S. O., Omidiji, E. A., & Adeleke, M. A. (2021). Genetic adaptation of indigenous poultry to local environments in the tropics. *Frontiers in Genetics*, *12*, 635487.

Sasanami, T., Matsuzaki, M., Mizushima, S., & Hiyama, G. (2013). Sperm storage in the female reproductive tract in birds. *Journal of Reproduction and Development*, *59*(4), 334–338. doi: 10.1262/jrd.2013-038

Talluri, T. R., Mal, G., & Ravi, S. K. (2017). Biochemical components of seminal plasma and their correlation to the fresh seminal characteristics in Marwari stallions and Poitou jacks. *Veterinary World*, *10*(2), 214–220. doi: 10.14202/vetworld.2017.214-220

Taniguchi, S., Zhu, Z., Matsuzaki, M., Tsudzuki, M., & Maeda, T. (2021). 5-Aminolevulinic acid improves chicken sperm motility. *Animal Bioscience*, *34*(12), 1912–1920. doi: 10.5713/ab.21.0021

Tenza, T., Mhlongo, L. C., Ncobela, C. N., & Rani, Z. (2024). Village Chickens for Achieving Sustainable Development Goals 1 and 2 in Resource-Poor Communities: A Literature Review. *Agriculture*, *14*(8), 1264. https://doi.org/10.3390/agriculture14081264