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PROXIMATE COMPOSITION, HEAVY METAL CONTENT AND MACROELEMENT PROFILE OF CHICKEN FEED SUPPLEMENTS FROM *Egeria radiata*(CLAM) AND *Tympanotonus fuscatus* (PERIWINKLE) SHELLS

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ABSTRACT
Poultry farming relies on feed supplements to maximize .growth by providing nutrients which may be lacking in their basic diets. This study evaluated the nutritional composition and safety characteristics of mollusk shell powders from *Egeria radiata* (clam) and *Tympanotonus fuscatus* (periwinkle) as alternative calcium supplements for poultry feed. Clams and periwinkles were collected from Ishiet River in Akwa Ibom State, processed into fine powder, and subjected to comprehensive proximate analysis, macroelements composition and heavy metal screening following standard methods. Results revealed that shell supplements exhibited predominant mineral composition with significant ($p < 0.05$) elevated ash content, relative to standard feed. Calcium and potassium content were also significantly ($p < 0.05$) higher in the shells compared to standard feed. *T. fuscatus* shells demonstrated significantly ($p < 0.05$) elevated iron content in comparison to *E. radiata* and feed. Heavy metal concentrations were below WHO/FAO permissible limits, with no detectable cadmium. Shell supplements demonstrated significantly ($p < 0.05$) low moisture content, and protein levels, likely representing residual organic matrix proteins. From the findings, it can be concluded that shell preparations had favourable compositional and safety characteristics. Nevertheless, controlled feeding trials remain essential for validating biological efficacy, establishing optimal inclusion rates, and assessing long-term performance outcomes in commercial poultry production systems.

Keywords: *Egeria radiata*, Heavy metals, Macroelement composition, Poultry nutrition, Proximate composition, *Tympanotonus fuscatus*

INTRODUCTION
Modern broiler farming is highly capital intensive as it often relies on various feed supplements to maximize growth, support immune function and improve overall productivity. Furthermore, use of commercial supplements has raised serious concerns about contamination with heavy metals and other harmful substances (Singh *et al.,* 2010). The processes involved in making these supplements, sourcing the raw materials, and storing them create multiple pathways through which contaminants like lead, cadmium, mercury, chromium, and arsenic can get into the feed (Khan *et al.,* 2016).
These heavy metals are persistent environmental pollutants that bioaccumulate in animal tissues even at low exposure levels, subsequently entering the human food chain as poultry products posing serious health risks to humans (Singh *et al.*, 2010; Gupta *et al.*, 2021). The accumulation of these toxic metals in broiler tissues can disrupt normal body functions, damage organs, weaken the body ability to fight oxidative stress, and impede animal welfare. Concerns are especially high about their effects on the liver and kidneys, which are the key sites in detoxification and excretion, and on antioxidant systems that protect against damage from heavy metals. Additionally, the continued use of synthetic growth promoters, antibiotics, and chemical additives as supplements in broiler feed has led to debates about their impact on poultry health, meat quality, consumer safety, and the emergence of antibiotic resistance.
Nigeria's ban on antibiotic growth promoters in 2018 has highlighted the urgent need for safe and effective alternatives for broiler feed supplements that can maintain production efficiency without compromising food safety or public health (Ayalew *et al.*, 2022). This has informed the need for exploring natural products to unravel their comparable efficacy.
The aim of the study therefore was to evaluate the proximate composition, macroelement content, heavy metal concentrations and vitamin profiles of feed supplements from *E. radiata* and *T. fuscatus* shells, thereby providing comprehensive compositional and safety data on these locally available marine resources, and establishing a scientific evidence for their potential application in sustainable poultry nutrition, while addressing critical concerns about feed safety, nutritional adequacy, and economic viability.

MATERIALS AND METHODS
Sample Collection and Preparation
Clams and periwinkles were collected from Ishiet River in Itu Local Government Area of Akwa Ibom State, Nigeria, and were thoroughly washed with clean water to remove surface contaminants and adhering debris. For periwinkle processing, the specimens were immersed in hot water for 20 minutes to soften the tissue and facilitate separation of the edible portion from the shell using a sharp needle. The empty shells were initially air-dried at ambient laboratory temperature and subsequently oven-dried at 105 °C for 24 hours to achieve constant weight. Clam tissues were carefully removed from the shells using a sterile sharp knife, after which the shells were thoroughly rinsed with clean water to eliminate residual organic matter. The cleaned shells were then subjected to the same drying procedure as described for the periwinkle shells. Upon complete drying, all shell samples were pulverized into fine powder using a mechanical grinder to obtain a homogeneous particle size suitable for further analysis. The resulting powder was sieved to achieve uniform particle size

distribution and stored in properly labeled, airtight containers pending chemical analysis. Standard feed (starter and finisher) were obtained from a reputable vendor in Uyo, Akwa Ibom State.

Proximate Analysis

Proximate analysis was conducted following the method described by the Association of Official Analytical Chemists (AOAC,1984).

Macroelements and Heavy Metal Analysis

Macroelements and Heavy metal analysis were conducted using Agilent FS240AA Atomic Absorption Spectrophometer according to the method described by American Public Health Association (APHA, 1995). Phosphorus content was determined colorimetrically following the AOAC methods (1984).

Statistical Analysis

Data were analyzed using SPSS software (version 16). Results were presented as mean ± standard deviation. One-way analysis of variance (ANOVA) followed by Duncan's post-hoc test was used to evaluate significant differences between test groups at a 95% confidence level (P<0.05).

RESULTS AND DISCUSSION

Proximate Analysis of Feed and shell powders

The results of proximate analysis of feed and shell powders presented in Table 1 show that moisture content, protein, fibre, carbohydrate and energy were significantly (p<0.05) higher in the feed than the shell powders. However, ash content was significantly (p<0.05) higher in the shell powders than the feed. Lipids were not detected in the shell samples.

Table 1: Proximate Analysis of Feed and Shell Powders

Parameters (%)	Starter Feed	Finisher Feed	*E. radiata* Shell Powder	*T. Fuscatus* Shell Powder
Moisture	8.73 ± 0.05^{a}	8.65 ± 0.01^{a}	3.01 ± 0.04^{b}	3.08 ± 0.02^{b}
Protein	23.74 ± 0.11^{a}	20.87 ± 0.01^{a}	3.88 ± 0.02^{b}	4.08 ± 0.01^{b}
Ash	4.20 ± 0.01^{b}	4.81 ± 0.02^{b}	65.94 ± 1.59^{a}	63.87 ± 1.09^{a}
Lipid	6.76 ± 0.27	7.21 ± 0.01	Not detected	Not detected
Fibre	6.21 ± 0.17^{a}	7.02 ± 0.12^{a}	0 04± 0.01^{b}	0.03± 0.01^{b}
Carbohydrate	50.36 ± 2.20^{a}	51.44 ± 1.28^{a}	27.12 ± 0.24^{b}	28.93 ± 0.21^{b}
Energy (kcal/mol)	375.24 ± 3.47^{a}	354.13 ± 6.24^{a}	124.09 ± 4.09^{b}	132.13 ± 4.01^{b}

Data are presented as Mean ± Standard Deviation (n=3)
Mean values in the same row with the same superscript show no significant difference (p>0.05)

Heavy Metal Concentration in Feed and Shell Powders

The result of heavy metal concentration in feed and shell powders presented in Table 2 shows that all the heavy metals tested were below the WHO/FAO limit; and there was no significant difference in the mean values of heavy metals recorded for all the samples.

Table 2: Heavy Metal Concentration (ppm) in Feed and Shell Powders

Samples	Lead	Cadmium	Mercury	Chromium	Aluminium	Arsenic
Standard feed (Starter)	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.01 ± 0.001^{a}	0.01 ± 0.001^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Standard feed (Finisher)	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.01 ± 0.001^{a}	0.01 ± 0.001^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
E. radiata Shell	0.01 ± 0.001^{a}	0.00 ± 0.00^{a}	0.01 ± 0.001^{a}	0.01 ± 0.001^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
T. fuscatus Shell	0.02 ± 0.001^{a}	0.00 ± 0.00^{a}	0.04 ± 0.002^{a}	0.01 ± 0.001^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}
WHO/FAO Limits (WHO, 1989)	5.0	1.0	0.1	2.0	8-10	2.0

Data are presented as Mean ± Standard Deviation (n=3)
Mean values in the same column with the same superscript show no significant difference (p>0.05)

Macro elements Composition of Feed and Shell Powders

The results in Table 3 showed that clam and periwinkle shells had significantly (p<0.05) higher calcium and potassium than feed. Also, iron content in periwinkle shells was significantly (p<0.05) higher than what was recorded for clam and commercial feeds.

Table 3: Macroelements Composition (ppm) of Feed and Shell Powders

Samples	Calcium	Phosphorus	Magnesium	Iron	Zinc	Selenium	Potassium
Standard feed (Starter)	11.48 ± 1.10^{b}	18.51 ± 2.00^{a}	11.38 ± 1.00^{a}	2.30 ± 0.10^{c}	5.10 ± 0.25^{a}	0.06 ± 0.00^{a}	11.67 ± 2.15^{b}
Standard feed (Finisher)	10.27± 0.55^{b}	19.29 ± 2.50^{a}	10.48 ± 0.75^{a}	5.74 ± 0.45^{b}	5.10 ± 0.28^{a}	0.10 ± 0.00^{a}	11.10 ± 1.95^{b}
E. radiata (Shells)	13.79 ± 1.50^{a}	13.82 ± 1.80^{b}	11.48 ± 1.51^{a}	2.52 ± 0.11^{c}	0.63 ± 0.08^{b}	0.10 ± 0.01^{a}	14.19 ± 2.50^{a}
T. fuscatus (Shells)	14.89 ± 1.55^{a}	18.01 ± 2.52^{a}	9.87 ± 0.85^{a}	8.54 ± 0.52^{a}	1.42 ± 0.08^{b}	0.09 ± 0.00^{a}	13.78 ± 2.40^{a}

Data are presented as Mean ± Standard Deviation (n=3)
Mean values in the same column with the same superscript show no significant difference (p>0.05)

Discussion

The intensification of poultry farming globally has required the exploration of alternative, cost-effective, and locally available feed supplements to replace expensive conventional mineral sources while maintaining optimal bird performance and product safety. This study analyzed proximate composition, heavy metals and macroelement contents of chicken feed and shell powders from *Egeria radiata* and *Tympanotonus fuscatus.*

The result of the proximate analysis showed shell-based supplements were predominantly mineral in composition, with a significant ($P<0.05$) higher ash content compared to the standard feed. This work agrees with the works of Opeh *et al.,* (2011) and Taylor *et al.,* (2007) which reported 60-70% ash content in mollusk shells, reflecting their primarily calcium carbonate composition. The significant ($P<0.05$) decrease in protein content observed in the shells likely represents residual organic matrix proteins including conchiolin and lustrin,which agrees with the report of Marin *et al.* (2012) where it was documented that structural proteins constitute approximately 1-5% of shell dry weight in bivalves and gastropods. The negligible lipid content in shell materials confirms the complete removal of soft tissue, which is expected given that mollusk shells are deposited from aqueous solutions through biomineralization processes that do not involve lipid incorporation (Addadi *et al*., 2006).

Heavy metal analysis demonstrated that the shell powders and commercial feed contained concentrations below the acceptable limits established by WHO/FAO (1989). There was no significant difference ($P>0.05$) in lead, cadmium, mercury, chromium, aluminium, or arsenic levels among any of the samples tested, indicating that the shell powders were comparable in heavy metal safety to commercial feeds. This finding challenges the assertion that commercial products are often purer than natural alternatives (Rumbeiha and Oehme, 2017), and suggests that appropriate harvesting and processing of mollusk shells from this locality does not introduce appreciable heavy metal contamination. The absence of cadmium in all samples is consistent with Effiong *et al*. (2021), who reported minimal cadmium in mollusk shells from Nigerian coastal regions, indicating limited environmental contamination. Notably, the absence of a significant ($P>0.05$) difference in lead, mercury, aluminum, and arsenic levels of the shells disagrees with findings that sediment-dwelling organisms tend to accumulate toxic substances (Taylor *et al.,* 2007; Udoinyang *et al*., 2022; Ekpo *et al*., 2015).

Mineral analysis revealed that *E. radiata* and *T. fuscatus* shell powder had significant ($P<0.05$) increase in calcium content confirming these materials as valuable calcium sources for skeletal development in poultry. This finding aligns with Lichovníková *et al., (*2020) established knowledge that calcium carbonate-rich mollusk shells can effectively supplement dietary calcium requirements in broilers. This result also agrees with Marin *et al., (*2012) who reported that mollusk shells typically contain 60-80% calcium carbonate by weight with substantial shell purity. The significant ($P<0.05$) increase in phosphorus levels in standard feeds compared to *E. radiata* shell powder correlates with Proszkowiec-Weglarz and Angel (2013) work suggesting that while shell powders contribute significantly to calcium intake, they must be combined with conventional feeds to maintain optimal calcium-to-phosphorus ratios critical for bone mineralization and egg shell formation. The high phosphorus content in *T. fuscatus* shells also raised concerns about calcium: phosphorus ratio imbalances at high inclusion rates, which agrees with previous work done by Walk *et al., (*2012) demonstrating that deviations from optimal Ca: P ratios (approximately 2:1) can impair skeletal development and mineral absorption efficiency in broilers. The notably high iron content in *T. fuscatus* shell is consistent with findings by Adeyemi and Sogbesan (2014), who attributed high iron concentrations in periwinkle shells to the iron-rich mangrove and estuarine sediments of their habitat, where passive deposition of iron oxides onto shell surfaces during growth is well established. Dietary iron is essential for haemoglobin synthesis, oxygen transport, and enzymatic activity in poultry, though elevated intake can interfere with phosphorus and zinc absorption (NRC, 1994), suggesting that the notably high iron in *T. fuscatus* shell warrants consideration during ration formulation to avoid antagonistic mineral interactions.

CONCLUSION

This study demonstrates that mollusk shell powders from *Egeria radiata* and *Tympanotonus fuscatus* represent promising alternative calcium sources for poultry nutrition, offering substantial mineral content and acceptable heavy metal safety profiles. The favorable compositional and safety profiles support continued investigation through controlled feeding trials to establish optimal treatment rates, validate biological efficacy, assess long-term safety, and develop comprehensive quality standards. With appropriate processing, quality control, and formulation optimization, marine mollusk shells could contribute to more sustainable, locally-sourced poultry nutrition systems, particularly valuable for resource-limited settings in tropical regions. However, the transition from promising compositional profiles to practical commercial application requires substantial additional research addressing biological performance, economic viability, and environmental sustainability under realistic production conditions.

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