

The gains and utilization of crayfish waste meal in broiler finisher diet

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ABSTRACT

Aim: Purpose of the study was to investigate the gains and utilization of crayfish waste meal in broiler finisher diet on the performance indices, haematological and biochemical indices and the impact on cost and returns.

Method and materials: Crayfish waste was collected, sorted and sieved to remove dirt. It was then milled into fine powdery substance to make crayfish waste meal. The crayfish waste meal was used to formulate four broiler finisher rations at 0.00%, 1.00%, 2.00% and 3.00% of 100kg of feed representing T1, T2, T3 and T4 respectively. Four groups of fifteen broiler finisher chicks of Agrited breed were randomly assigned to the four treatment diets in a completely randomized design and fed for 28 days. Each group was further subdivided into three replicates of five birds.

Results: The haematological indices revealed that at T4 (3.00% crayfish waste meal), haemoglobin, red blood cell, mean cell volume, mean cell haemoglobin concentration and clotting time were significantly increased $p < 0.05$ compared to the control, T1 (0.00% crayfish waste meal). Biochemical indices showed that total proteins, globulins, creatinine and urea were significantly increased at T4 (3.00% crayfish waste meal) compared to the control, T1 (0.00% crayfish waste meal). Cost and returns analysis showed that cost per kg weight gain and cost of feed consumed were reduced considerably at T4 (3.00% crayfish waste meal) with higher revenue and profit margin compared to the control, T1 (0.00% crayfish waste meal).

Conclusion: It was concluded that inclusion of crayfish waste meal to broiler finisher diet at 3.00% level reduced cost of feed consumed, gave higher revenue and gross margin profit without having any deleterious effect on performance and blood profile of the birds.

Keywords: Growth performance, profitability, blood indices, crayfish waste meal, broiler finisher diet

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Introduction

Sustainable intensification of broiler chicken's production as a major animal protein is currently restricted by numerous factors, including scarcity of feed ingredients and high feed cost (Steczny and Kokoszynski, 2020). Feed inputs scarcity and their consistent price increases could be attributed to the ever-increasing human population and a resultant higher demand for conventional feed materials such as maize, fish, soyabean, groundnut etc, for food, feed and biofuel sectors (Matshogo *et al.*, 2020). Fishmeal has been a common ingredient in poultry feed industry due to its high protein content, balanced amino acid profile, minerals, vitamins and omega - 3 fatty acid contents, flavor and palatability that encourages feed intake (Adeyeye, 2009). Despite these notable qualities,

supply instability and the exorbitant price value of fishmeal remains major crucial issues. Research studies are therefore focusing more on how to explore locally available proteinous agro-industrial by-products and farm waste which may be of low or zero commercialization in order to reduce feed cost and promote profitable livestock production. Asafa *et al.* (2012) stated that use of alternative/ non-conventional feedstuff is the best solution to overcoming feed ingredients scarcity and high feed cost. Agricultural by-products, food waste, indigenous plants, industrial by-products and insects are capable of providing nutrients that are essential for improvements in animal nutrition, performance and suggested practices (Sime *et al.*, 2025). Asafa *et al.* (2012) suggested that crayfish waste meal, a left over from crayfish processing, could serve as a promising alternative to the expensive fish meal in broiler diets, due to its comparable amino acid profile.

A review of the nutritional profile of crayfish waste meal revealed that it contains 48.08% crude

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protein, 6.55% ash, 4.03% other extract, 6.07% crude fibre and 35.29% nitrogen free extract, making it a suitable substitute for broiler diets (Ukoha *et al.* 2020). However, diverse reports have been given by researchers on the effects of crayfish waste meal on different livestock. It was observed that rabbits and broiler chickens fed up to 75 – 100% crayfish waste meal had no significant ($p>0.05$) treatment effects in their haematological and biochemical parameters, performance characteristics and nutrient digestibilities (Asafa *et al.*, 2012; Ukoha *et al.*, 2019 and Sime *et al.*, 2025). On the other hand, Ukoha *et al.* (2020) highlighted those high levels of crayfish waste meal in broiler diets drastically decreased feed intake and resulted to poor weight gain and feed conversion ratio compared to the control diet. Rybicka (2024) explained that crayfish meal has high fibre content compared to fishmeal, which may significantly impact on young monogastrics, due to increased digesta viscosity, reduced digesta passage rate and increased satiety, potentially reducing feed intake and weight gain. Conflicting results may exist regarding the effect of crayfish waste meal in broiler diets due to differences in specific processing methods, the overall diet composition and the crayfish waste inclusion levels (Olajide *et al.*, 2020).

This study therefore was aimed at investigating the gains and utilization of crayfish waste meal on broiler finisher diet.

Materials and Methods

Study Site

This feeding trial was conducted at Imo State University, Owerri Teaching and Research Farm (5°45' and 7°15'N; 6°50' and 7°25'E) within the southeast agro-ecological zone of Nigeria. The temperature ranges from 26°C – 29°C, with an annual average rainfall range of 2400 – 2500mm, at an elevation of 73m above sea level (Nimet, 2015).

Source and Processing of crayfish waste meal

The crayfish waste used to prepare the experimental diets was procured from crayfish marketers at Ekeukwu market, Owerri Imo State. Other feed ingredients were sourced at CEEKINGS Farm Feed Mill Egbu in Owerri. The crayfish waste bought was sorted using tray to remove impurities. The dried waste was milled into a fine powder, thereby making crayfish waste meal. The meal was then packaged in polythene bags and stored in a cool dry place to maintain quality. Small quantity of the crayfish waste meal was sent to laboratory for proximate analyses. The proximate composition

of crayfish wastes meal were analyzed according to Association of Official Analytical Chemists (AOAC, 2010) to determine the percentage dry matter and the dry matter percentages of Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE), Ash and Nitrogen Free Extract (NFE).

Experimental Diets

Four broiler finisher diets were formulated incorporating crayfish waste meal at 0.00%, 1.00%, 2.00%, and 3.00% per 100kg feed representing T1, T2, T3 and T4 respectively and partly replacing fishmeal on weight-to-weight bases.

Experimental Birds and Design

Sixty (60) Agrited four weeks (28 days) old broiler chickens bought from a reputable dealer in Owerri were used for the experiment. The birds were randomly divided into four groups of 15 broilers and each group was randomly assigned to one of the four treatment diets in a completely randomized design (CRD). Each group was replicated thrice with 5 birds per replicate and housed in a deep litter compartment measuring 1m x 1m. Feed and water were provided *ad libitum*. The trial lasted for 28 days.

Data collection

Data were collected on feed intake and body weight changes. The birds were weighed at the beginning of the experiment to obtain their initial body weights and thereafter on weekly basis. Daily feed intake was determined by subtracting the weight of leftover feed from the weight of the feed given the previous day. Feed conversion ratio was calculated by dividing the average daily feed intake by average daily weight gain.

Blood collection and analysis

On the 28th day of the study, three birds were randomly selected from each treatment (that is one bird per replicate) and blood samples collected from each bird through the wing vein, with sterile needles and syringes. 8mls of blood were drawn from each bird. 3mls of blood were put in the specimen bottle with ethylene diamine tetra acetic acid (EDTA) for determination of haematological indices whereas 5mls of blood were put in the specimen bottles without EDTA for biochemical indices analyses. Only the bottles labeled for haematological studies contained anticoagulant ethylene diamine tetra acetic acid (EDTA). The haematological parameters; Packed Cell Volume (PCV), Haemoglobin (Hb), Red Blood Cell (RBC), Mean Cell Volume (MCV), Mean Cell Haemoglobin (MCH), mean cell haemoglobin

concentration (MCHC), White Blood Cell (WBC), Lymphocytes, Monocytes, Basophil, Neutrophil, Eosinophil, Erythrocyte Sedimentation Rate (ESR) and clotting time were determined at the laboratory unit of Federal University Teaching Hospital Owerri, Imo State within three hours of collection. Blood samples for serum biochemistry were equally analyzed for total serum protein, Albumin, Globulin, Creatinine, Urea, Cholesterol, Alkaline phosphatase (ALP), Alanine transferase (ALT), Aspartate transferase (AST), Potassium (K) Chlorine (Cl), Bicarbonate (HCO_3) and Sodium (Na) at the same laboratory. The analyses were done according to the procedures outlined by Ochie and Kolhatkar (2000).

Cost and returns of adding crayfish waste meal in the diets

The market price of each feed ingredients as at the time of the study was used to determine both the total cost of feed/kilogram of diet and the total cost of feed consumed per bird. Feed cost per kilogram was calculated by adding the prevailing price of the different feed ingredient per kilogram. The cost per kilogram live weight gain was calculated as feed conversion ratio (FCR) multiplied by cost per kilogram of diet. Revenue was calculated as price per kilogram meat, multiplied by the average weight gain. Profit was calculated by subtracting the cost of production from the revenue realized through sales of birds.

Statistical analysis

Data collected and subjected to one way analysis of variance using the SPSS software (2012). Significant means were compared using Duncan's New Multiple Range Test (DNMRT) (SPSS, 2012).

Results and Discussion

Proximate composition of crayfish waste meal

The crayfish waste meal used for the studies contained crude protein, ether extract, ash, crude fibre and nitrogen free extract (Table 2). The percentage compositions of these nutrients varied slightly from the proximate results of Okoye (1998) and Asafa *et al.* (2012). The report from Ukoha *et al.* (2019) that crayfish waste meal contains 48.08% crude protein, 4.03% ether extract, 6.07% crude fibre, 29-35% nitrogen free extract and 6.55% ash were completely in line with this study. Crayfish waste meal is made up shrimps, shells, exoskeletons, sea debris and other organic matter, the crude protein varies from 30-70% depending on these components (Olomu, 2010). Conflicting

proximate results may therefore exist due to differences in processing methods and compositions. This proximate result suggests that crayfish waste meal contains high level of dietary protein that could support broilers performance like fishmeal.

Performance of the experimental broiler finisher birds

Data on the performance characteristics of broiler finisher chickens offered different levels of crayfish waste meal diets are presented in Table 3. Performance data revealed that there was no significant difference $p>0.05$ on all parameters measured such as mean final weight, mean weight changes, mean daily feed intake and feed conversion ratio. T4 (3.00%) gave higher meat yield, higher feed intake per day and higher daily weight gain compared to the rest treatments including the control but not significantly $p>0.05$. They performance were statistically similar to T1 (0.00%). T2 and T4 had a better feed conversion ratio compared to the control but not significantly $p>0.05$. Feed intake progressively increased as the inclusion levels of crayfish waste meal increased in the diets but not significantly. The feed conversion ratios were close to the values 2.48 to 3.19 reported by Asafa *et al.* (2012) on effects of crayfish waste meal on performance characteristics and nutrient retention of broiler finishers and lower than the values 3.50 to 4.63 reported by Ukoha *et al.* (2012) on comparative evaluation of fishmeal, crayfish waste meal and blood meal for broiler production. There was no significant difference $p>0.05$ in the feed conversion ratio in this trial. Meyer (1986) reported that crayfish waste meal has a comparable amino acid profile with fish meal and when the feed is similar in composition dry matter intake and gain would not be different which explains the non-significant difference in the mean daily feed intake, weight gain and feed conversion ratio. The values for the feed conversion ratio were higher than the reference range 1.7 to 2.0 for broilers (Ghosh 2015).

Haematological and biochemical indices of the experimental broiler finisher birds

Data on the haematological and biochemical indices are presented in Tables 4 and 5 respectively. Blood profile is a reflection of the pathophysiological responses of animals to the environment (feed, temperature, diseases, contaminants etc.) (Kamboh *et al.*, 2018). There was no significant difference $p>0.05$ in the packed cell volume (PCV %).

Table 1. Ingredient and calculated nutrient compositions of the broiler finisher bird

Ingredients	Treatment Levels of the CWM (%)			
	T ₁ (0.00)	T ₂ (1.00)	T ₃ (2.00)	T ₄ (3.00)
Maize	60.00	60.00	60.00	60.00
Soyabean Meal	20.00	20.00	20.00	20.00
Fish Meal	3.00	2.00	1.00	0.00
Crayfish Waste Meal	0.00	1.00	2.00	3.00
Wheat Offal	8.00	6.00	6.00	6.00
Palm Kernel Cake	4.00	4.00	4.00	4.00
Palm oil	1.00	1.00	1.00	1.00
Bone Meal	3.00	3.00	3.00	3.00
Common Salt	0.25	0.25	0.25	0.25
Vit. / Mineral premix	0.25	0.25	0.25	0.25
L-lysine	0.25	0.25	0.25	0.25
DL-Methionine	0.25	0.25	0.25	0.25
Total	100kg	100kg	100kg	100kg
Calculated nutrient composition of the diets				
Crude Protein (%)	19.23	19.08	18.93	18.73
Crude Fibre (%)	3.97	3.98	3.99	3.99
Ether Extract (%)	5.82	5.72	5.62	5.52
Metabolizable energy (Kcal/kg)	2921.63	2890.17	2863.70	2837.23

Table 2. Proximate composition of crayfish waste meal

Parameters	Proximate compositions (%DM)
Dry Matter	83.45
Crude Protein	48.07
Ether Extract	4.06
Ash	6.53
Crude Fibre	6.09
Nitrogen Free Extract	35.26
ME (Kcal/kg)	3361.45

Table 3. Performance indices of broiler finisher chickens fed graded levels of crayfish waste meal (cwm) in the diet

Parameters	Treatment Levels of CWM (%)				
	T ₁ (0.00)	T ₂ (1.00)	T ₃ (2.00)	T ₄ (3.00)	SEM
Mean initial body weight (g)	1420.00	1358.33	1410.00	1416.67	22.25
Mean final body weight(g)	2832.32	2895.53	2822.04	3011.55	71.42
Mean weight change(g)	1412.32	1537.20	1412.04	1594.88	79.06
Mean daily weight gain (g)	50.44	54.90	50.43	56.96	3.44
Mean daily feed intake (g)	137.44	140.25	142.99	149.47	7.70
Feed conversion ratio (g feed/g weight gain)	2.73	2.60	2.85	2.62	0.18

Table 4. Haematological indices of broiler finisher chickens offered graded level of crayfish waste meal

Parameters	Treatment Levels of CWM (%)				
	T ₁ (0.00)	T ₂ (1.00)	T ₃ (2.00)	T ₄ (3.00)	SEM
Packed cell volume (%)	35.27	35.67	31.50	37.67	1.90
Haemoglobin (g/dl)	11.70 ^b	11.90 ^b	11.60 ^b	12.60 ^a	0.12
Red Blood Cell Count (X10 ¹² /L)	4.24 ^b	4.28 ^{ab}	4.26 ^b	4.35 ^a	0.03
Mean cell Volume (fl)	81.43 ^b	81.73 ^b	81.71 ^b	82.67 ^a	0.14
Mean Cell Haemoglobin (Pg)	27.40 ^b	27.70 ^b	27.40 ^b	28.20 ^a	0.13
Mean cell Haemoglobin Concentration (g/dl)	32.44 ^b	32.50 ^{ab}	32.44 ^a	32.53 ^a	0.02
White blood cell count (X10 ⁹ /μl)	25.33	30.67	36.33	29.67	6.03
Lymphocytes (%)	29.00 ^b	32.33 ^{ab}	37.33 ^a	36.33 ^{ab}	2.61
Monocytes (%)	3.00	4.00	4.67	2.67	1.28
Basophil (%)	1.33	2.00	2.00	1.67	0.37
Neutrophil (%)	0.00	0.00	0.00	0.00	0.00
Erythrocyte Sedimentation rate (mm ³ /1 st 1hr)	20.33	20.33	20.33	25.00	2.31
Clotting time (s)	9.67 ^c	13.33 ^a	10.00 ^{bc}	13.00 ^{ab}	0.94

abc means within the same row with different superscripts are significantly different (p<0.05)

SEM = Standard Error Mean, CWM = Crayfish waste meal

Table 5. Biochemical indices of finisher broiler chickens fed graded levels of crayfish waste meal

Parameters	Treatment Levels of CWM (%)				SEM
	T ₁ (0.00)	T ₂ (1.00)	T ₃ (2.00)	T ₄ (3.00)	
Total protein (g/dl)	3.10 ^b	3.50 ^{ab}	3.13 ^b	4.00 ^a	0.27
Albumin (g/l)	1.70 ^{ab}	1.20 ^c	1.43 ^{bc}	1.83 ^a	0.11
Globulin (g/l)	3.03 ^b	3.77 ^a	2.90 ^b	3.77 ^a	0.05
Creatinine (mmol/l)	0.13 ^b	0.20 ^a	0.10 ^b	0.20 ^a	0.02
Urea (mmol/l)	0.50 ^c	2.53 ^{bc}	4.90 ^b	5.33 ^a	0.75
Cholesterol (mmol/l)	88.00 ^a	94.67 ^a	70.33 ^b	98.67 ^a	3.35
Potassium (mmol/l)	3.93 ^{ab}	3.83 ^{ab}	3.60 ^b	4.47 ^a	0.23
Chloride (meq/l)	97.07	97.67	101.07	100.33	1.96
Sodium (mmol/l)	136.33	135.66	132.00	137.33	4.28
Aspartate aminotransferase (%)	89.67	115.00	112.33	73.00	21.39
Alanine aminotransferase (%)	2.33 ^c	6.33 ^a	3.33 ^{bc}	5.33 ^{ab}	0.83
Alkaline phosphatase (%)	604.00 ^b	729.00 ^a	700.67 ^{ab}	640.00 ^{ab}	35.13

abc means within the same row with different superscripts are significantly different ($p < 0.05$)

SEM = Standard Error Mean

Table 6. Cost and returns analysis of broiler finisher birds fed crayfish waste meal diets

Parameters	Treatment Levels of CWM (%)			
	T ₁ (0.00)	T ₂ (1.00)	T ₃ (2.00)	T ₄ (3.00)
Mean weight changes (g)	1412.32	1537.20	1412.04	1594.88
Feed conversion ratio (g feed/g wt gain)	2.73	2.60	2.85	2.62
Cost of feed/kg (N)	890	860	830	800
Cost of feed/kg weight gain (N)	2,429.70	2,236.00	2,365.50	2,096.00
Mean Feed intake/bird/ 28 days (g)	3848.32	3927.00	4003.73	4185.96
Cost of feed intake/ bird/ 28 days (N)	3425.00	3377.22	3323.32	3348.13
Selling price/ kg meat	4000	4000	4000	4000
Revenue/bird (N)	5649.28	6148.8	5648.16	6379.52
Gross profit/bird (N)	2,224.28	2771.58	2324.84	3031.39

CWM= Crayfish Waste Meal

Packed cell volume percent is the volume percent red blood cells in circulating blood (Purves *et al.* 2003). Demoranville and Best (2013) reported that PCV below the normal range is a pointer to liver and kidney diseases, malnutrition of vitamin B12 and folic acid deficiencies. The PCV % fall within the normal reference value 25-45% (Banerji, 1998). Packed cell volume of the birds was similar ($p > 0.05$) across the four treatment groups indicating a better transport of oxygen and absorbed nutrients due to increase in the number of Red Blood Cells (Aster, 2004). The haemoglobin (HB) was significantly increased at T4 compared to T1, T2 and T3. HB is an important determinant of anaemia (Wikivet, 2013). The values for HB were within the normal reference value 7-13g/100ml reported by Banerji (1998) and Jain (1989). Esiegwu *et al.* (2017) reported that normal values of PCV and haemoglobin imply normal physiological functioning and effective gaseous exchange within the blood. Red blood cell revealed that T4 (3.00 % crayfish waste meal) was significantly increased compared to the control T1 (0.00 % crayfish waste meal). The inclusion of crayfish waste meal at 3.00% level improved the red blood cell volume compared to the fishmeal. The values of PCV %, HB and RBC

for the crayfish waste meal indicate that crayfish waste meal had no deleterious effect, toxic or any dangerous pathological effect on the blood of the broiler. It showed superior blood building action on the birds compared to fishmeal. The mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) showed significant treatment effect. T4 (3.00 % crayfish waste meal) was significantly increased $p < 0.05$ compared to the rest treatment and control for MCV, MCH, and MCHC. The MCV, MCH and MCHC were within the normal reference value reported by Swenson (2004) and Banerji (2013). The values of MCV, MCH and MCHC were a sign of intact immune system (Esiegwu and Obih, 2019) and also implies that the production of red blood cell by the bone marrow was adequate across treatments (Esiegwu and Obih, 2022). There was no significant treatment effect $p > 0.05$ on the white blood cells meaning that there was no infection arising as a result of the consumption of the crayfish waste meal. This infers that crayfish waste meal did not inflict any pathological damage on the haematological indices, as evidenced by absence of basophil, which is rare in normal blood and only released in areas of inflammations.

The serum biochemical result (Table 5) revealed that total protein, globulin, urea and creatinine were significantly ($p < 0.05$) increased at T₄ diet (3.00% CWM) compared to T₁ diet (control). This showed that CWM promoted protein metabolism at 3.00% inclusion level in the finisher broiler chickens. High level of urea was reported by Nworgu *et al.* (2007) as a sign of low protein quality due to imbalance in amino acid. Increased creatinine secretion is common where there is increased metabolism of muscle protein (Imaseum and Ijeh, 2018). The electrolyte levels were normal and had no treatment effects across the four treatment groups, except for the potassium, where the concentrations were below the normal range of $4.60 - 6.56 \pm 0.41$ mmol/L for chicken, as described by Alriton (1952) in T₁, T₂ and T₃ treatment groups. This could result to muscle tone and cause fatigue to the animals.

Three liver enzyme markers and cholesterol values did not follow a definite pattern implying that test ingredient had no definite effect on these important serum parameters. Data from Tables 4 and 5 have proved that the test ingredient never influenced the blood indices of the finisher broiler birds negatively, as earlier documented by Obi (2019); Olajide *et al.* (2020) and Ukoha *et al.* (2020).

Cost and returns analysis

The high cost of feed in T₁ was due to the high cost fishmeal. The feed cost reduced at T₄ where crayfish waste meal was used solely without inclusion of fish meal. Cost per kg weight gain was highest at T₁ compared to other treatments because of high cost of fish meal and poor feed conversion ratio (high value for feed conversion ratio). Cost of feed consumed rose very high at T₁ compared to other treatments due to high cost per kg weight gain and relatively low average weight changes. T₄ showed a higher revenue earnings and better gross margin due to low cost of crayfish waste meal, effective performance of the crayfish waste meal in producing heavier average weight change and better feed conversion ratio compared to the rest treatments.

Crayfish waste meal as a source of animal protein was cheaper than fishmeal and this contributed to the reduced cost of feed (Table 6) coupled with the excellent performance observed in the meat yield and feed conversion ratio. Therefore, it is more economical to utilize some of these agricultural wastes of animal protein sources to improve performance of broilers and earn higher returns on investment due to cost effectiveness.

Conclusion

The use of crayfish waste meal as a protein source in broiler finisher chicken was beneficial in improving average weight gain at 3.00% inclusion level. The study also revealed that crayfish waste meal at 3.00% inclusion level reduced cost/kg weight gain, increased revenue earnings and gross margin. The study also revealed that crayfish waste meal improved the blood profile of broiler finishers especially the haemoglobin and red blood cell. There was no negative or deleterious effect on the blood profile of the broiler finisher chickens. It was therefore concluded that crayfish waste meal was cost effective and improved meat yield leading to higher revenue earnings and gross profit margin.

Recommendations

It was therefore recommended that crayfish waste meal could serve as an alternative animal protein source in broiler finisher ration at up to 3.00% inclusion level for cost effectiveness and higher revenue earnings. Future researches should test the use of higher levels of crayfish waste meal in broiler finisher ration.

References

- Adeyeye EI (2009). Proximate composition and mineral content of some Nigerian fish meal. *Journal of Food Science and Technology*, 46(3): 245-249.
- Albritton AB (1952). Standard values in blood. Philadelphia, W.B. Saunders Beckman Synchron LX system chemistry. Information manual, 2001.
- AOAC (2010). Official methods of analysis of the association of official's analytical chemists. 19th Edition, Association of Official Analytical Chemist, Washington D.C. USA.
- Asafa AR, Ologhobo AD and Adejumo IO (2012). Effect of crayfish waste meal on performance characteristics and nutrient retention of broiler finishers. *International Journal of Poultry Science*, 1(11): 496-499.
- Aster JC (2004). Anaemia of diminished erythropoiesis in V. Kummer, A.K., Abbas, N. Fausto, S.L., Robbins and R.S. Cotran (Eds), Robbins and Cotran Pathologic Basis of Disease (7th Ed.). Saunders Co. 638-649. Philadelphia.
- Banerjee S, Mukhopadhaya S, Haldar S, Ganguly S, Pradhan S, Patra N, Niyogi D and Isore D (2013). Effect of phytogenic growth promoter on broiler birds. *J. Pharmacogn*

- Phytochem, 1(6): 183-188.
- Banerji GC (1998). A Textbook of animal husbandry. 8th ed. Oxford and IBH pub ltd. 118-143.
- Demoranville VE and Best MA (2013). Haematocrit Encyclopaedia of Surgery. A guide for patients and caregivers. Available at en.wikipedia.org/wiki/haematology.
- Esiegwu AC and Obih TKO (2019). Growth performance, haematological and serum biochemical indices of broiler finisher birds fed fermented Bambara meal (*Vigna subterranean* (L) VERDC). Direct Research Journal of Veterinary Medicine and Animal Science. 4(4): 3339
- Esiegwu AC and Obih TKO (2022). Growth performance, haematological serum indices and histopathology of finisher broiler chickens offered nutritional supplement of comfrey (*Symphytum officinale* L) leaves extract. Asian Research Journal of Agriculture, 15(4): 254-265.
- Esiegwu AC, Okorie KC, Ikpe JN and Oko EC (2017). The feed value of toasted *Mucuna slonaei* meal on the performance, haematology and blood biochemistry of broiler finisher birds. Journal of Agriculture and Food Sciences, 15(1): 1-12.
- Ghosh N (2015). Poultry Science and Practice. A Textbook. CBS Publishers and Distributors PVT Limited.
- Imaseum JA and Ijeh OA (2018). Effect of diet supplemented with two sources of antioxidants as feed additive on growth indices and internal organs of broiler chickens. Nigeria Journal of Animal Production, 4(5): 73-81.
- Jain NC (1989). Veterinary haematology. 4th ed. Philadelphia: Lea & Febigar.
- Kamboh AA, Khan MA, Kaka U, Awad EA, Memon AM, Saeed M, Korejo NA, Bakhregul M and Kumar C (2018). Effect of Dietary Supplementation of Phytochemicals on Immunity and Haematology of Growing Broiler Chickens. Ital. J. Anim. Sci. 17: 1038-1038.
- Matshogo TB, Mnisi CM and Mlambo V (2020). Dietary green seaweed compromises overall feed conversion efficiency but not chickens. Agriculture, 10: 547.
- Meyers SP (1986). Utilization of shrimp processing wastes. Infofish Marketing Digest, 486: 18-21.
- Nigerian Meteorological Agency (Nimet) (2015). Nigeria climate review bulletin Nimet. Gov.ng/content/nimetweather.
- Nsa EE and Essien AI (2019). Growth performance of broiler chickens fed maize offal and crayfish-waste based diets. Nigerian Journal of Animal Production, 46(3): 263-269. <https://doi.org/10.51791/njap.v46i3.990>
- Nworgu FC, Ogungbero SA and Solesi SS (2007). Performance and some blood chemistry indices of broiler chickens served fluted pumpkin (*Telfairia occidentalis*) leaf extract supplement. AM Eurasian J Agric Environment, 2(1): 90-98.
- Obi TKO (2019). Blood Indices of Broiler Finisher Birds Fed Varying Dietary Level of Crayfish Waste Meal. Direct Research Journal of Veterinary Medicine & Animal Science, 4(6): 71-75.
- Ochie J Kolhatkar (2000). A Medical Laboratory Science. Theory and Practice. Tata McGraw-Hill Company Limited New Delhi.
- Okoye FC (1998). The replacement value of shrimp waste meal (SWN) for local fish (LFM) in the diet of broiler chickens. Proceedings of the Anniversary Conference NSAP, 261.
- Olajide S, Adeleye O and Akinyemi OD (2020). Effects of replacing local fish meal with crayfish dust on the growth performance, blood profile and carcass characteristics of broiler chickens. Bulletin of Animal Health and Production in Africa, 68(1): 31-39.
- Olumu JM (2010). Monogastric [sic] on raw materials for feed production in nigeria characteristic nutritive values, levels of inclusions in animal diets and possible limitations. Pizak Industrial Graphics, Kaduna Nigeria.
- Purves WK, Sadava D, Onans GH and Heller HC (2003). Life: The Science of Biology. (7th ed.) Sunderland Mass Associates, 954.
- Rybicka A (2024). Effect of fibre concentrate addition on performance and digestive health in young monogastrics. Thesis Doctora; E.T.S. de ingenieria Agronomica, Alimentariay de Biosistemas (UPM).
- Sime AG and Bekana SD (2025). The role of NON-conventional small Ruminant Production and their Implications for Feed Cost Reduction in Ethiopia – A Mini Review, Vet Sci., 11(5): e 70554. doi: 10.1002/vms3.70554.
- SPSS Software (2012). Statistical package for Social Sciences. Version 21- IBM Corporation.

- Steczny K and Kokoszynski D (2020). Effect of probiotic preparation (EM) and sex on morphometric characteristics of the digestive system and leg bones, and caecal microflora in broiler chickens. *J. Appl. Anim. Res.* 2020, 48: 45-50.
- Swenson MJ (1977). *Dukes' physiology of domestic animals*. 9th edition CBS publishers Pvt Ltd. Indian, 14-35.
- Ukoha OA, Nsa EE, Onunkwo DN and Ezike JC (2019). Comparative evaluation of crayfish waste, meat and blood meal for broilers production, 46(1): 71-76. DOI: <https://doi.org/10.51791/njap.v46i1.32/>
- Wikivet.net (2013). Chicken haematology. Available at en.wikipedia/wiki/haematology.
