https://dx.doi.org/10.4314/dujopas.v11i3c.27
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 11 No. 3c September 2025*

Growth Performance and Feed Utilization Efficiency of Broiler Chickens Fed Different Physical Forms of Commercial Starter Diets

Ibrahim, B. [1], Mabu, I. M. [2], Ibrahim A. [3], Bello A. A.[4]

[1]Ministry of Agric and Natural Resources Veterinary Section,
Funakaye Local Government,
Gombe State,
Nigeria.

[2]Desert Research Monitoring and Control Centre,
Yobe State University,
Damaturu,
Nigeria.

[3]Federal Polytechnic Damaturu,
Nigeria.

[4]Federal Ministry of Livestock,
Abuja,
Nigeria.

Email: isamusamabu64@gmail.com

Abstract
The experiment was conducted to evaluate the growth performance of broiler chicken fed three different commercial diets tagged A, B and C feed at starter phase. Two-hundred-day-old broilers were used for the experiment. They were allotted to the three diets in three replicates in a Completely Randomized Designed. Feed and water were supplied ad-libitum throughout the research period. Among the performance parameters studied were daily weight gain (DWG), Feed conversion ratio (FCR) and feed use efficiency (FE) were significantly affected. Their values ranged from 48.66-56.01, 1.73-2.03, 0.49-0.58, respectively. However, weight at four (4) weeks and mortality were significantly influenced (P<0.01). Similarly, Daily Feed Intake (DFI) and Initial Weight was not influenced by the feed forms. T1 and T2 diets demonstrated superior growth performance and economic efficiency, with T1 (Marsh) proving to be the most cost-effective. Overall, the results highlight that the choice of feed form should be guided not only by growth outcomes but also by economic viability, particularly in low-resource production systems. It was concluded from the finding of the research that feed form has significant effect on the productive performance of broiler chicken at starter phase.

Keywords: Feed, chicken, performance, experiment and growth

INTRODUCTION

Broiler production is recognized globally as one of the most efficient and cost-effective methods of supplying high-quality animal protein to humans. In regions like Europe and North America, poultry meat is often favored over beef due to its superior protein content, lower calorie count, and desirable qualities such as tenderness (FAO, 2021). Its flexibility in

**Author for Correspondence*

processed forms makes it particularly popular in fast food outlets like Mr. Biggs and Kentucky Fried Chicken, which rely heavily on broiler meat for their offerings (Okoli, 2021). Historical evidence traces poultry domestication as far back as 3200 BC (Sanotras *et al*., 2021). Today, broiler farming contributes significantly to global meat production, with research efforts focused on improving bird growth, feed utilization, and production efficiency.

One important factor affecting broiler performance is the physical form of feed, especially during the starter phase when birds are forming feeding habits and developing their digestive systems (Amerah *et al*., 2007). Commercial starter diets typically come in mash, pellet, and crumble forms, each with different processing methods and particle sizes. These forms impact feed palatability, intake, digestion, and nutrient use (Dozier *et al*., 2010; Nir *et al*., 1995). Pelleted feeds tend to enhance growth and feed efficiency by reducing wastage and encouraging faster consumption. On the other hand, mash feeds support better gut development due to slower digestion rates. Understanding these feed characteristics is essential for optimizing broiler health, productivity, and overall performance (Abdollahi *et al*., 2013). Poultry feeds are carefully formulated to meet the nutritional demands of specific growth phases in birds. However, studies have shown that switching between different commercial feed brands can lead to over a 10% decline in broiler performance, indicating significant variability in nutrient composition among brands, even when labeled for the same purpose (Uchiegba *et al*., 2019). This underlines the importance of evaluating feed quality to ensure maximum productivity.

The starter phase is a critical period in broiler growth, with nutritional input during this stage having lasting effects on body development and carcass traits (Ferket and Gernat, 2006). Thus, assessing the influence of feed form on performance metrics such as weight gain, feed intake, and feed conversion ratio (FCR) during this stage is essential. Feed manufacturers often produce broiler diets (starter, super starter, and finisher) with claimed nutrient values, yet many fall below recommended standards (Afolabi *et al*., 2013). Farmers, attracted by lower prices and lacking the technical skill to formulate their own feed, unknowingly purchase and use these substandard products beyond recommended periods. As a result, both farmers and consumers are vulnerable to exploitation by commercial feed producers (Uchegbu *et al*., 2017). Product inconsistencies lead to poor animal performance and customer dissatisfaction (Khusro *et al*., 2012). In response to widespread complaints, regulatory bodies like SON, NIAS, and NAFDAC have initiated efforts to improve quality control. However, high management costs including feeding, vaccination, and sanitation remain a major challenge for producers.
This study was therefore designed to evaluate the growth performance and feed efficiency of broiler chickens fed different physical forms of commercial starter diets. The ultimate aim is to provide insights for more effective feeding strategies and to analyze the economic implications of using these various feed forms in broiler production.

MATERIALS AND METHODS

Study area

The experiment was conducted at the teaching and research farm, Department of Animal Production, Abubakar Tafawa Balewa University, Yelwa Campus, Bauchi, state, Nigeria. Bauchi state occupies a total land area of 49,119km^2 respectively about 5.3% of Nigeria's total land mass and is located between latitude $9^0$3″ and $12^0$3″ north and longitude $8^0$5″ and 11^0 easts. The projected population of Bauchi State **is** approximately 9.28 million as of 2025 (NBS, 2025). The state is bordered by seven (7) states, Kano and Jigawa to the north, Taraba and Plateau state to the south Gombe and Yobe to the east and Kaduna to the west. Bauchi state is one of the states in the northern part of Nigeria that span two distinctive vegetation zones:

Namely the Sudan savannah and the Sahel savannah. The rainfall in Bauchi state ranges between 1300mm per annum in the south and only 700mm per annum in the extreme north NPC, (2006). This pattern is because in the West Africa sub-region, rains generally, come from the south as they are carried by the south-waterless. Bauchi state has a total of 55 tribal groups in which Hausa, Fulani, Gerawa, Sayawa, Jarawa, Kirfawa, Turawa, Bolewa, Kare kare, Kanuri, Fa'awa, Butawa, Warjawa, Zulawa, Boyawa are the main tribes. This means they have background occupational patterns, beliefs and many other things that form part of the existence of the people of the state. There are cultural similarities in the people, language, occupational practices, festivals dress, and there is high degree of ethnic interaction especially in marriage and economic existence. Some of the ethnic groups have joking relationships that exist between them, Iloeje, (2001).

Experimental Design and Management of Birds

Total of Two hundred (200) broiler birds were used for the experiment. The birds were divided into three (3) treatments groups of 60 chicks each in three replicates of 20 birds, after a successful 10 days of brooding. The birds are reared in a deep litter housing system with feed and water provided *adlibitum*. Left over feed and body weight of birds were recorded on weekly basis and routine vaccination (Lasota and Gumboro) were given as recommended. Feed intake was recorded daily and weight gain was also taken on weekly basis.

Experimental Diets

Three (3) broiler starter diets of different selected commercial forms were purchased and labeled as diet 1, 2 and 3 which were given to treatment groups as T1, T2 and T3 respectively. The three feeds differ in proximate composition of ME, crude protein, crude fibre, ether extract among others.

Data Collection

Performance parameters

Feed intake

Feed consumptions from each treatment were measured on daily basis by taking the difference between feed given and left over.

Daily weight gain

This was achieved by weighing the birds at the beginning of the experiment and recorded as initial weight. Birds were weighed weekly and daily weight gain was obtained by calculating the difference between two (2) consecutive weighing divided by number of days and number of birds.

Feed conversion ratio (FCR)

Feed conversion ratio was calculated as follows:

$$FCR = \frac{Feed\ intake}{weight\ gain}$$

Mortality rate

The mortality of each treatment was recorded as it occurs

Statistical Analysis

Data generated during the experiment were subjected to analysis of variance (ANOVA) technique as outlined by Steel and Torrie (2022).

Table 1: Ingredients Composition of the Experimental Diets Poultry at Starter level Determined at Level of Inclusion

Parameters	T1 Marsh	T2 Crumbles	T3 Pellets
Metabolizable Energy	2650	2900	2900
Crude Protein	19%	22%	18%
Crude Fibre	5.00	5.00	5.00
Ether Extract	5.00	6.00	6.00
Calcium	1.00	1.00	1.00
Phosphorus	0.40	45	0.40
Lysine	1.00	1.20	0.25
Methionine	0.40	0.30	0.35
Salts	0.30	0.30	0.30

Key: T1 = Mash, T2 = crumbles and T3 = Pellets

Table 2: Laboratory determined proximate compositions of the experimental diets

Parameters	T1 Marsh	T2 Crumble	T3 Pellet
Dry Matter (%)	88.70	89.63	89.11
Ash (%)	10.62	10.57	9.73
Crude Protein (%)	22.74	22.64	22.66
Ether Extract (%)	8.68	8.69	5.26
Crude Fibre (%)	5.20	5.26	5.36

Key: T1 = Mash, T2 = crumbles and T3 = Pellets

RESULTS AND DISCUSSION

Growth Performance of Broiler Chickens Fed Different Commercial Feeds (1-4 weeks)

The data summarize the growth response of broiler chickens fed three different dietary treatments (T1, T2, and T3). The parameters evaluated include starting body weight, average daily feed intake, daily weight gain, feed conversion ratio (FCR), feed efficiency, final weight, and mortality rate. Statistical differences are shown, with "" indicating significance at $P < 0.01$, "*" at $P < 0.001$, and "NS" meaning the variation was not statistically significant.

Initial Weight and Feed Intake

The initial weight ranges from 72.53g to 52.53g with the highest in diet 2 (crumble) followed by marsh in diet 1 with 71.67g, respectively. The initial body weights of birds across the three treatments were statistically similar ($P > 0.01$), ranging from 71.67 g in T1 to 74.63 g in T2 and 72.53g in T3. This indicates that the chicks were evenly allocated at the beginning of the study, ensuring a fair comparison. This result is similar to initial weight obtained by Opara *et al*., (2020) in their study on the growth performance and carcass characteristics and on administration of *Ocinum gratissimum* (scent leaf) extract of boilers chicken fed three forms of commercial feed where he recorded 38.56g, 38.54g and 38.59g across all the diets.

The average daily feed intake ranges between 95.91g to 98.65g on diet 3 (pellet), followed by crumble in diet 2 with 96.65g, and the lowest feed intake was found in diet 1 with 95.91g respectively. The non-significant effect recorded in this study indicated that the three forms of feed were significantly the same in their effect on the daily feed intake across all the treatments. The values range between 95.91g in diet 1 marsh, 96.65g in diet 2 crumble and 98.65g in diet 3 pellet. Although birds on T3 consumed slightly more (98.65 g) than those on T1 (95.91 g) and T2 (96.65 g), the variation was not meaningful. This suggests that the form or brand of the feed did not impact the birds' appetite or voluntary consumption this coincides with the findings of Abdollahi *et al*. (2013), who noted that feed form may not greatly affect intake when diets are similar in nutrient content. Similarly, Uchegbu, *et al*., (2017) reported a

non-significant effect across the treatments (53.00g to 75.55g) in his study comparative effect of self-formulated feeds and 4 commercial diets on the growth performance, carcass and hematological parameters of broilers starter in the tropics. His findings are also similar to the values obtained by Sanusi, (2015). In the performance of broilers chicken fed with local formulated feed and commercial feed.

Daily Weight Gain

The lowest average daily weight gains of (48.66g) was observed in diet 3, followed by crumble in diet 2 with 55.76g, while the highest was recorded in diet 1 (56.01g) respectively. The daily weight gain shows that there was significant influence (P<0.05) on the daily weight gain of the birds at the end of the starter level. A significant difference ($P < 0.01$) was observed in daily weight gain among the groups. Broilers on T1 and T2 gained more weight per day (56.01 g and 55.76 g, respectively) than those fed T3 (48.66 g). This implies that the nutritional quality or physical structure of the T3 feed may have been less favorable for efficient digestion and absorption. This finding aligns with the outcome of the research by Dozier *et al.* (2010), who reported that pellet quality and nutrient density are key factors influencing broiler performance. The daily weight gain (56.93g to 56.96g) values obtained were in contrast to the report of Uchegbu *et al*., (2017) who reported low diet led to poor performance. The result is in contrast with the findings by Sanusi., (2015) who reported average daily weight gain between 26.73g to 43.36g.

Feed Conversion Ratio and Feed Efficiency

The feed conversion ratio was significantly (P<0.01) influenced by dietary treatment of 1.71g, 173g on diets 1, 2 and 2.03g on diet 3, respectively. Birds on T3 showed the least efficient feed utilization with a FCR of 2.03, compared to more desirable values of 1.71 and 1.73 in T1 and T2, respectively. A lower FCR indicates better efficiency, as birds require less feed to gain a unit of weight, a crucial consideration in commercial poultry production (Nir *et al*., 1995). The findings from this research are in agreement with what was reported by Opara *et al*., (2020) of 1.74g, 1.75g and 2.05g respectively. The lowest feed efficiency was found in diet 3 (0.49g) followed by marsh in diet 1 with 0.58g. Similar with the value found on crumble in diet 2 (0.58g) respectively. Correspondingly, feed efficiency**,** which is the inverse of FCR, was superior in T1 and T2 (0.58) compared to T3 (0.49). This reinforces the conclusion that broilers on T3 converted feed into body mass less effectively as compared to those on T1 and T2 respectively. Similar patterns were reported by Amerah *et al*. (2007), who highlighted the influence of feed form and processing on nutrient utilization which is in agreement to what was reported by Opara *et al*., (2020) of 1.74g, 1.75g and 2.05g respectively.

Final Body Weight

The weight at 4 weeks of age were found to be significantly (P<0.01) different on diet 1, 2 and 3 which ranged from 1636-1435g, respectively. The final body weights **of** Birds on T1 and T2 Significantly reaching approximately 1640 g and 1636 g, respectively, whereas birds in T3 only attained 1435 g. These results further confirm the superior growth performance of T1 and T2, likely as a result of better nutrient formulation or more efficient feed processing techniques. this is in line with the report of Okoli *et al*., (2022) who reported 1.3kg-1.42kg live weight after first phase. This depends on the level of energy used in the ration. In his study "Assessment of Mycoflora of Commercial Poultry Feed Sold in the Tropical environment".

Mortality Rate

The mortality of 10 birds was recorded on diet 1, 2 and 3 where in both diets 1 and 2, 0.33 mortality was recorded. And on treatment 3 highest mortality was recorded with (3.33) respectively. The mortality recorded during the experiment was due to outbreak of

Coccidiosis (*Eimeriosis*) towards the end of the starter phase. Mortality rates varied significantly across treatments ($P < 0.001$). T3 experienced the highest mortality at 3.33%, as against the much lower 0.33% observed in T1 and T2. The increased mortality in T3 could be as a result of poor feed quality, nutritional imbalances, or unsuitable physical form, which may have negatively affected bird health and digestive function. Ferket and Gernat (2006) also noted that inadequate early nutrition can impair immune response and increase susceptibility to disease, leading to higher losses.

Table 3: Growth Performance of Broiler Chickens Fed Different Commercial Feeds (1-4 weeks)

Parameters (g)	T1	T2	T3	SEM	Significance
Initial weight (g)	71.67	74.63	72.53	1.16	NS
Daily feed intake(g)	95.91	96.65	98.65	8.93	NS
Daily weight gain (g)	56.01^{a}	55.76^{ab}	48.66^{b}	2.09	**
Feed conversion ratio(g)	1.71^{a}	1.73^{a}	2.03^{b}	0.14	**
Feed efficiency (g)	0.58^{a}	0.58^{a}	0.49^{b}	0.10	**
Final weight gain (g)	1640^{a}	1636^{a}	1435^{c}	57.74	**
Mortality	0.33^{a}	0.33^{a}	3.33^{b}	0.33	***

Key: T1 = Mash, T2 = crumbles and T3 = Pellets

Cost Benefit Analysis of Three Different Types of Broiler Feeds Used at Starter Level

The findings show that Diets 1 (Marsh) and 2 (Crumble) were more economical compared to Diet 3 (Pellet). Birds fed Diet 3 recorded the highest daily feed intake at 0.099 kg, while the lowest intake was observed in Diet 1 at 0.096 kg. The cost of daily feed intake per bird ranged from ₦23.62 in Diet 1, ₦24.44 in Diet 2, to ₦24.75 in Diet 3. Similarly, the cost per kilogram of weight gain was ₦414.39, ₦428.77, and ₦515.63 for Diets 1, 2, and 3, respectively. The table assesses the economic viability and growth efficiency of broiler chickens fed three differently processed feed types Marsh (T1), Crumble (T2), and Pellet (T3) based on major performance metrics including feed price per kg, daily feed consumption, weight gain, and feed cost per kg of weight gain.

Feed Cost Per Kilogram: Feed prices were fairly close, with T1 (₦246/kg) being the cheapest, followed by T3 (₦250/kg), and T2 (₦252/kg) being the most expensive. The modestly higher costs of crumble and pellet feeds reflect the additional processing involved, such as pelleting and crumbling, which increase production expenses (Dozier *et al.*, 2002).

Daily Feed Intake: Feed intake rose marginally with the degree of processing: 0.096 kg (T1), 0.097 kg (T2), and 0.099 kg (T3). This is in agreement with the earlier research suggesting that pelleted feeds improve palatability and reduce wastage, encouraging barely higher consumption (Amerah *et al.*, 2007; Abdollahi *et al.*, 2013). Despite small differences, such variations can be economically important when applied to large-scale production.

Daily Feed Cost Per Bird: Reflecting both feed price and intake, T1 (Marsh) sustained the lowest daily cost (₦23.62), while T3 (Pellet) had the highest (₦24.75). This underscores an important consideration for poultry producers: although pelleted feeds may enhance feed consumption, they also lead to higher daily feeding expenses, (Leeson and Summer, 2001).

Daily Weight Gain: Birds on T1 and T2 experienced the highest daily weight gain (0.057 kg), whereas T3 resulted is the lowest (0.048 kg), despite greater intake. This indicates that higher intake with pellets did not lead to improved growth, possibly due to lower nutrient utilization efficiency or heat-related stress associated with greater consumption (Nir *et al.*, 1995).

Additionally, improper pelleting temperatures can reduce amino acid bioavailability (Abdollahi *et al*., 2011).

Feed Cost Per Kilogram Weight Gain: This metric further emphasizes cost-efficiency. T1 (Marsh) had the lowest cost per kilogram of weight gain (₦414.39), followed by T2 (₦428.77), while T3 (₦515.63) was the least economical. These findings substantiate earlier conclusions that higher feed processing levels do not always translate to better productivity or profitability (Dozier *et al*., 2002; Laudadio *et al*., 2014).

Table 4: Cost Benefit Analysis of Three Different Types of Broiler Feeds Used at Starter Level

Parameters	T1 Marsh	T2 Crumble	T3 Pellet
Feed cost ₦/kg	246	252	250
Daily feed intake (kg)	0.096	0.097	0.099
Cost of feed intake (₦)	23.62	24.44	24.75
Daily weight gain (kg)	0.057	0.057	0.048
Cost of feed per weight gain (₦/kg)	414.39	428.77	515.63

Key: T1 = Mash, T2 = crumbles and T3 = Pellets

CONCLUSION

In summary, broilers fed with T1 (Marsh) and T2 (Crumble) diets performed better than those on T3 (Pellet) in terms of growth rate, feed conversion ratio (FCR), and survival rate. Although feed intake showed no significant variation among the treatments, there were notable differences in parameters such as weight gain, FCR, feed efficiency, final body weight, and mortality rate. These findings emphasize the critical role of feed quality and physical form in optimizing broiler performance, especially during the starter phase. Despite the potential of pelleted feeds (T3) to increase consumption, they failed to enhance growth or reduce feeding costs in this trial. T1 and T2 diets demonstrated superior growth performance and economic efficiency, with T1 (Marsh) proving to be the most cost-effective. Overall, the results highlight that the choice of feed form should be guided not only by growth outcomes but also by economic viability, particularly in low-resource production systems.

RECOMMENDATIONS

Based on the conclusions drawn from the study, the following recommendations are proposed:

1. Poultry farmers should prioritize Marsh and Crumble Feeds During the Starter Phase: Farmers should consider using Marsh (T1) and Crumble (T2) diets during the early growth stages of broiler production, as these feed forms showed superior performance in growth rate, FCR, and survival compared to Pellet (T3).
2. Feed Forms should be Selected based on both Performance and cost efficiency: selection of feed should not be based solely on intake levels or appearance but must factor in overall cost-effectiveness and bird performance, particularly in resource-limited settings.
3. The use of Pellet Diets Without Performance Gains should be avoided by poultry farmers:
   Given that pelleted feeds did not significantly improve weight gain or reduce feeding costs, its use should be limited or reconsidered unless specifically justified by other operational advantages (e.g., automation compatibility).
4. Farmers should be educated on the Impact of Feed Form when starting to poultry farms:
   Extension programs and advisory services should train poultry farmers on how the

physical form of feed influences broiler productivity and economic gains, especially during the critical starter phase.

5. Feed Quality Standards and Monitoring should be Encourage by the authorities: Regulatory bodies and producers should collaborate to maintain high feed formulation standards, ensuring that feeds not only meet nutritional specifications but also are optimally processed for performance and profitability.
6. Feed Strategies Tailored towards Local Economic Conditions should be adopted: In low-resource or smallholder systems, adopting more affordable and effective feed forms like Marsh can help maximize returns and sustainability in broiler production.

REFERENCES

Abdollahi, M. R., Zaefarian, F., & Ravindran, V. (2013). Feed processing effects on poultry: Role of feed form and feed processing in optimizing poultry diets. *Animal Production Science*, 53(6), 560–569. https://doi.org/10.1071/AN12376

Abdollahi, M. R., Zaefarian, F., and Ravindran, V. (2011). Influence of pelleting temperature on performance, nutrient retention and energy utilization in broiler starters fed diets containing soybean meal. *Animal Feed Science and Technology*, 168(1-2), 88–99.

Abdollahi, M. R., Zaefarian, F., and Ravindran, V. (2013). Feed processing: effects on the nutritional value of poultry feed. *World's Poultry Science Journal*, 69(3), 573-586.

Afolabi, K. D., Akinsoyinu, A. O., Olajide, R., and Akinlade, J. A. (2013). Evaluation of the nutrient composition of some commercial poultry feeds in Nigeria. *African Journal of Agricultural Research, 8*(25), 3273–3277. https://doi.org/10.5897/AJAR12.1251

Amerah, A. M., Ravindran, V., Lentle, R. G., and Thomas, D. G. (2007). Feed particle size: Implications on the digestion and performance of poultry. *World's Poultry Science Journal*, 63(3), 439–455. https://doi.org/10.1017/S0043933907001602

Dozier, W. A., Gordon, R. W., Morgan, G. W., and Blaylock, R. B. (2002). Growth, feed conversion, and carcass traits of broiler chickens fed crumbled or pelleted diets during growth to thirty-five days of age. *Journal of Applied Poultry Research*, 11(3), 291–297.

Dozier, W. A., Kidd, M. T., and Corzo, A. (2010). Effects of feeding pelleted vs. mash feed on performance of broiler chickens. *Journal of Applied Poultry Research*, 19(3), 311–318. https://doi.org/10.3382/japr.2010-00154

FAO (Food and Agriculture Organization of the United Nations). (2021). *Poultry Sector: Key Facts*. Rome: FAO. Retrieved from http://www.fao.org/poultry-production-products/en/

Ferket, P. R., and Gernat, A. G. (2006). Factors that affect feed intake of meat birds: A review. *International Journal of Poultry Science*, 5(10), 905–911.

Iloeje, N. P. (2001). *A New Geography of Nigeria* (Revised Edition). Longman Nigeria Plc.

Khusro, A., Mandal, A. B., & Singh, B. P. (2012). Quality control in feed production. *World's Poultry Science Journal, 68*(4), 671–680. https://doi.org/10.1017/S0043933912000806

Laudadio, V., Passantino, L., Perillo, A., Lopresti, G., and Tufarelli, V. (2014). Productive performance and bone characteristics of broiler chickens fed different dietary protein levels and reared under heat stress. *Poultry Science*, 93(8), 2106–2115.

Leeson, S., and Summers, J. D. (2001). *Nutrition of the Chicken* (4th ed.). University Books.

National Population Commission (NPC) and National Bureau of Statistics (NBS). (2006). *Population and Housing Census of the Federal Republic of Nigeria: Priority Tables (Vol. 1).* Abuja: NPC.

National Population Commission (NPC) and National Bureau of Statistics (NBS). (2025). *Population and Housing Census of the Federal Republic of Nigeria: Priority Tables (Vol. 1).* Abuja: NPC.

Nir, I., Hillel, R., Shefet, G., and Nitsan, Z. (1995). Effect of particle size on performance. 1. Corn. *Poultry Science*, 74(6), 960–970. https://doi.org/10.3382/ps.0740960

Okoli, I.C., Nweke, C.U., Okoli, C.G, and Opara, M.N. (2022). Assessment of the mycoflora of commercial poultry feeds sold in the tropical environment of Imo State, Nigeria. *International Journal of Environmental Science and Technology*,3(1):9-14.

Okoli, I.C., Omede, A.A., Opara, M.C., Uchegbu, M.C. and Enemuo, V. (2021). Biochemical, physical and performance Evaluations of some commercial broiler Rations produced in Nigeria; Journal of Agriculture and social Research (JASR).

Opara (2020). Opera News Africa; Broilers research market size in 6 weeks of age. 12-16.

Sanotas, *et al*., (2021). Laser enrichment device stimulate broiler following laser behavior while increasing individual bird locomotion and pen-wide movement. Doi: 10.33891

Sanusi, (2015). Comparative of self-formulated and 4 commercial diets on the growth performance, carcass and hematological parameters of broilers starter and finishers in the tropics. *Sokoto Journal of Veterinary Sciences,* 13(2), 14-19.

Steel R.gd. and Tories, J.H. (2022). Principles of statistics. A biometrical approach. 2nd Edn. MC Grow Hill book co. inc New York, USA.

Uchegbu, M.C., Irechukwu, N.M., Omede, A.A., Nwaodu, C.H., Anyanwu, G.A., Okoli, I.C., and Udedibie, A.B.I. (2017) Comparative Evaluation of Three Commercial feeds on the performance of Broilers. *Report and opinion*, 1(4).

Uchiegba *(*2019). In search of food: FUTO and the nutritional challenge of canavalia seeds. 6th inaugural lecture of the Federal University of technology, Owerri, Nigeria.