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The Effects of Three Commercial Grower Feeds on Performance, Internal Organs, and Carcass traits in Pullet Chickens

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ABSTRACT

Poultry farming is categorized as a developing business venture in most countries, especially Nigeria. This is followed by poultry feed production units ranging from smaller compartments to commercial poultry feed producers. This research study was carried out to examine the physical, and biochemical parameters of feed, growth performance, carcass traits, and visceral organs of pullets fed selected commercial grower feeds and formulated diet. A total number of 1200 *Isa Brown* pullets aged 10 weeks were divided into 4 groups with 5 replicates for each group randomly. This research experiment was completed within 8 weeks. All poultry feeds were filled inside standard polyethylene woven bags in the absence of insects/mold. All poultry feeds, including Top Feed, Chikun Feed, and formulated diet were grouped into mash form except one of the commercial feeds Vital Feed in the pelleted form which is the treatment of the research. There were significant differences in final body weight, weight gain, feed consumed, and feed conversion ratio among the experimental treatments. The least weight was recorded among hens fed Vital feeds with the highest feed intake, which might be due to high fiber content in the feed. The dietary treatment significantly affects the live weight, dressed weight, neck, breast muscle, liver, kidney, gizzard, and abdominal fat of pullet fed different commercial feed and formulated diets. The findings of the current study indicated that a self-formulated diet at the grower stage could replace the commercial poultry feeds used in the study.

Keywords: Body weight, Carcass traits, Grower feed, Pullets, Visceral organs

INTRODUCTION

To control the health and well-being of chickens, proper feeding is essential. In most nations, particularly Nigeria, this is followed by poultry feed production units ranging from small-scale production of feeds to commercial poultry feed producers (Akinola and Ekine, 2018). Ethical feed production practices are established features of small animal industries in developed and developing countries; however, it is quite different in developing countries and executed in different ways. For instance, in Nigeria, there is no definite system for checkmating the quality and quantity of poultry feeds sold to farmers. Poor quality feeds result in a high death rate and low production. These resulted in low returns on capital investment (Griffioen et al., 2020). Many feed producers in Nigeria reduce the nutritional qualities required for poultry by including low-quality feed substances during feed formulations. However, knowing the nutritional requirements has a great value for the digestibility, biochemical composition, and the presence/absence of prominent anti-nutritional factors (Dobermann et al., 2017). Moreover, the essential nutrients in poultry feeds could not remain constant as a result of some factors, such as time, storage period of feed ingredients, and methods of poultry feed processing (Noblet et al., 2021). Feed producers do not usually consider these factors before feed production.

Income obtained for poultry production is greatly dependent on feed utilization, which accounts for 70-80% of the total production cost (Thirumalaisamy et al., 2019). Hence, it is very important to ensure safe feed quality with appropriate nutritional values suitable for effective production (Kalam et al., 2021). The present study aimed to examine the physical, and biochemical parameters of feeds and the performance of selected commercial grower feeds frequently used by farmers.

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MATERIALS AND METHODS

Collection and preparation of test ingredients

The experiment was conducted at the Teaching and Research Farm, Federal University, Oye Ekiti, Nigeria. It has an average annual temperature ranging from 21°C to 28°C with high humidity of over 75%. A general survey was conducted for the poultry feed producers. After the survey, lists of 5 commercial feed brands were chosen. The three most popular brands were purposively chosen from this study and feed superiority was established for brands having close to five brands accepted by farmers within the city for standard utilization and palatability. The selected poultry feed brands were coded with two lettered words Top Feed (TF), Vital Feed (VF), and Chikun Feed (CF). The formulated diet was coded as FF. The batches of sampled poultry feeds did not stay more than one week during storage to reduce feed quality deterioration. Selected commercial poultry feeds were bought from different outlets. Feed samples were taken and analyzed appropriately. For the specific brand of commercial grower feeds, 25 g of feed were taken from each bag purchased at different times during the current study. The feed samples were mixed before chemical analysis. This was carried out for each brand of commercial poultry feeds and formulated diet was produced separately. However, every two weeks of development during the study period, 25 g of formulated feed was obtained for sample analysis and appropriately mixed before chemical analysis for adequate evaluation.

Management of experimental animals

A total of 1200 *Isa Brown* pullets aged 10 weeks were used in this study. Young chickens of the same live body weights were randomly assigned to four dietary treatments. Each group used a brand of commercial grower feed and a formulated diet and was replicated five times. The chickens were housed in battery cages of 300 pullets per treatment and 60 chickens per replicate. The experimental design was a completely randomized design (CRD). Routine and standard management practices were carried out (Kalam et al., 2021). Daily feed requirement was weighed and fed to the chickens as per *Isa brown* and water were supplied *ad libitum*. This study lasted for 8 weeks from July to August 2020.

Experimental diet

There were four dietary experimental groups, namely T_1 (Top Feed), T_2 (Chikun Feed), and T_3 (Vital Feed Diets). T_1, T_2, and T_3 were commercial feeds bought from different commercial producers while diet T4 is a formulated diet (NRC, 1994) serving as a control dietary treatment as shown in Table 1.

Physical examination and proximate analysis of feed

Each feed brand purchased for poultry feed was weighed and recorded. Feed content was also calculated. The nutrient contents displayed on each bag label were recorded to ensure a proper understanding of nutritional content. The categories of feed were either pellet, mash, or crumble and were recorded accordingly. Furthermore, feed ingredient was weighed and examined for the presence of insects/mold, caking and even odors of the feed materials before feed production.

Data collection

Data were collected for feed intake (FI), feed conversion ratio, and body weight gain. Pelleted feed was weighed and supplied to pullets at the commencement of the week. The feed leftover was also weighed at the end of each week to determine FI for the period of the experiment as FI = Feed supply minus feed leftover (FS-FL). Furthermore, the birds were weighed on day 1 for initial body weight, followed by weekly weighing throughout the experimental period.

Table 1. Physical characteristics of the commercial layer feeds used in diet of *Isa brwon* chickens

Brand of feed	Declared wt. (kg)	Actual weight (kg)	Feed texture	Foreign bodies	Mould	Flavor	Cost per kg ($)
TF	25	24.6	Mash	NP	NP	Fresh	0.28
CF	25	24.9	Mash	NP	NP	Fresh	0.27
VF	25	24.8	Crumble	NP	NP	Fresh	0.27
FF	25	25	Mash	NP	NP	Fresh	0.25

NP: Not present, N.B: All feeds were packaged in standard polyethylene woven bags (pwb), wt: Weight. TF: Top feed, CF: Chicken feed, VF: Vital feed, FF: Formulated feed.

Carcass evaluation and organs measurement

After the 8 weeks of the feeding trial, five birds per treatment were randomly selected for analysis of carcass traits and organ parameters (Ekeocha and Afolabi, 2012). Feeds were withdrawn overnight and the chickens were slaughtered using human slaughtered techniques through mild electrical stunning to induce unconsciousness before slaughter, de-feathered, processed, and then eviscerated (Webster et al., 1996). Weights of the carcass, cut-off parts (head, neck, wing, breast, back, thigh, drumstick, and leg), and internal organs (heart, crop, gizzard, spleen, small intestine, large intestine, caeca, abdominal fat, and cloaca) were recorded. Caeca weight was recorded using a sensitive scale and tap rule (Sano et al., 2021). The dressing percentage was calculated. It is determined by dividing the carcass weight by the live weight, then multiplying by 100.

Metabolic trial

A number of 50 birds per treatment were randomly selected for the study. The birds were tagged, weighed, and housed separately in metabolic battery cages. Adequate feeding troughs and drinkers, including the facility for collecting fecal matter, were available. The birds were acclimatized for seven days in the cage and weighed feed was given to the birds for 14 days and their faces were collected each day for 14 days early in the morning. Fecal samples were sundried, weighed, and kept in a polythene bag inside a refrigerator for further analysis.

Statistical analysis

The Methodology Statistical analysis of discrimination issues was made using the Statistical Package for the Social Sciences (SPSS), version 18. The research data obtained from this experimental study were analyzed using a one-way Analysis of Variance (ANOVA). The significant differences among means were tested at a significant level of 0.05 using Tukey's test.

RESULTS AND DISCUSSION

Biochemical evaluation of selected grower feed

Table 2 present the proximate composition concerning the brands of commercial grower feeds. The proximate composition was compared to the displayed feed quantity on the bag labels. No feed producer indicated the moisture content of poultry feeds. However, on laboratory analysis, the feed moisture contents ranged from 4.5 to 6% (4.5% in VF, 5.7% in CF, 6% in TF, and 6% in FF). These values were better than that of poultry feeds stored without deteriorating within a short period of time (3 months).

Table 2. Comparison analyzed and nutrient compositions of different commercial grower feed fed to pullet chickens of *Isa brwon* breed

Parameters \ Feed	TF	CF	VF	FF
Declared moisture (%)	ND	ND	ND	ND
Analysed moisture (%)	6.00^{a}	5.70^{b}	4.50^{c}	6.00^{a}
Declared crude protein (%)	15.00^{a}	15.00^{a}	13.00^{b}	ND
Analysed crude protein (%)	15.57^{d}	16.70^{b}	16.10^{c}	17.50^{a}
Declared fat (%)	5.00^{b}	4.00^{c}	8.00^{a}	ND
Analysed fat (%)	7.10^{a}	7.30^{a}	6.70^{b}	7.10^{a}
Declared fibre (%)	7.00^{b}	6.00^{c}	15.00^{a}	ND
Analysed fibre (%)	5.80^{b}	5.90^{b}	6.20^{a}	5.70^{b}
Declared metabolizable energy (k cal)	2450.00^{b}	2600.00^{a}	2600.00^{a}	ND
Analysed metabolizable energy (k cal)	2300.00^{d}	2400.00^{b}	2350.00^{d}	2500.00^{a}
Declared calcium (%)	1.00^{a}	1.10^{a}	0.90^{a}	0.10^{a}
Analyzed calcium (%)	0.45^{b}	0.53^{b}	0.56^{b}	1.85^{a}

Means on the same row with different superscripts are significantly different ($p < 0.05$). T1, T2, and T3 were commercial feeds bought from different commercial producers while diet T4 is a formulated diet serving as a control dietary treatment. TF: Total feed, VF: Vital feed, CF: Chikun feed, FF: Formulated feed, ND: Not defined

This result was in contrast with the results obtained by (Akinola and Ekine, 2018) who had moisture contents ranging from 10% to 13.35%, which was above the optimum recommended range (10-12%). The high

moisture percentage supported the growth/development of fungi in the feed store for a long period (Sharma, 2019). The result of crude protein content analyzed in hosen grower's feeds was slightly higher than the protein content values displayed on all brands of poultry feeds. Akinola and Ekine (2018) also reported a slight increase in the crude protein value analyzed in broiler feed than the values displayed on brands of poultry feeds. The percentages of the crude fat content of the selected commercial grower feeds were higher than the values displayed on bag labels. Although this serves as a source of energy, excessive fat content in the feed has a limiting effect on poultry birds, for example, prolapse which causes fat deposition in the abdominal region. Furthermore, excessive fat content in the feed also augments oxidative rancidity and possible offensive odor. This led to feeding deterioration within a short period of time.

Laboratory analysis of crude fiber percentage and metabolizable energy for the selected commercial poultry feeds were less than the values displayed on bag labels. The reduction of crude fiber and metabolizable energy values for the selected commercial grower feeds could be ascribed to the high cost of feed ingredients. Hence, poultry feed producers set their goals to maximize their profit through which they may produce low-quality feed.

Performance evaluation

Table 3 presents the performance of pullet hens fed with commercial grower feeds and formulated diet for 8 weeks. The final body weight/weight gain of hens was higher in formulated grower feed (FF) than the bodyweight noted in commercial grower feed (VF, $p < 0.05$). Sharma (2019) reported that during the process of pullets from 7 to 16 weeks of age, the pullets fed with formulated diets added more weight ($p < 0.05$) than pullets fed with the commercial grower diet. This performance could be attributed to the quality of the feed ingredients used in diet formulation. Energy and protein concentrations in the diet pose an important function in livestock productivity and are critical in evaluating poultry performance (Alagawany et al., 2020). It was reported that the genetic ability of chickens can only be realized in case of adequate nutrient intake under some variable environmental conditions (Madhuri et al., 2020). This might require updates to the nutrient recommendations for poultry. Poultry diets must be formulated to give nutrient requirements for chickens if optimum growth is to be achieved (Oluwadele et al., 2020).

There was a significant difference in feed intake ($p < 0.05$) with hens fed with commercial feed (VF). Furthermore, the highest feed conversion ratio was noticed in hens fed with commercial feed (VF), while the least feed conversion ratio was noted in hens fed FF ($p < 0.05$). Sanusi et al. (2015) reported significant differences in growth performance, average daily feed consumed, daily weight gained, and FCR of the chicken fed with a self-formulated diet and four different commercial feed. Compared to high performance in hens fed with VF commercial feed can be linked to the pelleted form of the feed which enhances feed intake. Pelleting is known to improve feed intake in broilers and pullets regardless of the grain source (Mudhunguyo and Masama, 2015). These improvements could be associated with a high density, improved digestibility of starch emanating from chemical changes during the process of pelleting, increased nutrient intake, variations in physical characteristics, reduction in feed wastage, and low energy spent for consumption (Gopi et al., 2019).

The dietary treatment significantly ($p < 0.05$) affected the live weight, dressed weight, neck, breast muscle and thigh of the pullet fed different commercial grower rations and formulated diet. However, no significant effects ($p > 0.05$) were recorded on the dressing factor and organs including the head, wings, back, drumstick, and feet.

Tables 4 and 5 showed carcass traits and visceral organs of pullet hens fed with the chosen commercial grower feeds and formulated diet for eight weeks. This result supported the study conducted by Sanusi et al. (2015), who reported a significant difference in live weight, plucked weight, dressing percentage, carcass weight, and the weight of the pancreas. Similar research observations were also carried out by Sanusi et al. (2015) also reported significant ($p < 0.05$) effects of diet on the gizzard, spleen, and adipose tissue found in the abdomen. The highest gizzard weight was observed in hens fed with formulated diet (FF, 55.20 g) as compared to other dietary treatments, which ranged from 46.8 to 52.4 g. These findings could be linked to high fiber contents in diets of hens fed with VF and FF. These findings were similar to the published reports by Varastegani and Dahlan (2014). They all concluded that feeding high fiber diets can increase the length and weight of intestines, and other visceral organs. The growth of the poultry digestive system, with respect to the gizzard, is also influenced by feed particle size. This development is also obvious in chickens reared to their 7 days of age (Williams et al., 1996). It was reported that greater gizzard shape

development and lower pH in 7-day old chicks fed with medium or coarse particle feed size diets compared with chicks fed with fine particle diets which indicates a steady growth as the chicks are fed (Lee, 2021). The gizzards exert a mechanical pressure which may surpass 585 kg/cm^2 (Rubio, 2018). This may lead to poor gizzard development and enlarged proventriculus when broilers or pullets consume finely grounded, administered diets (Taylor and Jones, 2004). Hence, in these conditions, the gizzard plays the role of a transit organ and not a grinding organ (Zhao et al., 2021). It was observed that hens on diet VF had the lowest carcass quality. This could be attributed to the feeding form and also the low nutrient quality displayed on the feed bag. This could not meet up the nutrient requirement of the birds for optimum performance. Furthermore, this act of including low protein and energy source in the feed is a result of feeding (pelleted) which tend to increase the cost of production, and feed miller has to reduce the quality and quantity of the feed ingredients used in manufacturing the feed in order to minimize the cost of production and maximize profit at the detriment of the chicken performance fed with the balanced diet. Similar findings were reported by Hussein et al. (2001), indicating that highest level of protein which is treatment T2 (Chikun feed). Cost evaluation for a self-formulated diet was cheaper with the least cost of $ 0.24/ kg feed. The present finding was similar to the findings of Apantaku et al. (2006). The highest feed cost of $ 0.38$0.29 per kg was recorded on the VF diet. Sanusi et al. (2015) also reported that a self-formulated diet was easy and cheap to produce and it had the lowest cost of feed. Table 5 presents the visceral features of pullet fed with different commercial feed and formulated diets. Dietary treatment had a significant effect on the weight of liver, kidney, gizzard, and abdominal fat ($p < 0.05$), while the dietary treatment had no significant effect on spleen, heart, proventriculus, lungs, small intestine, large intestine, empty crop, caeca and duodenal loop of the chickens fed with different experimental diets.

Table 3. The effect of commercial grower feeds on the performance of *Isa brwon* pullet chickens

Parameters \ Feed brand	TF	CF	VF	FF
Initial body weight (g/hen)	550	540	540	540
Final body weight (g/hen)	1290^{a}	1250^{ab}	1180^{b}	1340^{a}
Total body weight (g/hen)	4281.2^{b}	4252.08^{b}	4494^{a}	4361.84^{ab}
Weight gain (g/hen)	327.6^{b}	319.76^{b}	283.92^{c}	393.68^{a}
Feed Conversion Ratio	1.22^{b}	1.44^{ab}	1.69^{a}	1.2^{b}

Means on the same row with different superscripts differ significantly ($p < 0.05$). $^{a, b, c}$ means different superscripts in the same column differ significantly ($p < 0.05$). TF: Top feed, CF: Chicken feed, VF: Vital feed, FF: Formulated feed.

Table 4. The effects of dietary treatment with different commercial grower feeds on live weight, dressing percentage, and carcass parameters of *Isa brwon* pullet chickens

Parameters	T_1	T_2	T_3	T_4
Live wt (g)	1360^{ab}	1396^{ab}	1318^{b}	1570.00^{a}
Dressed wt (g)	929.80^{ab}	970.80^{ab}	912.40^{b}	1076.60^{a}
Dressing (%)	68.33	69.57	69.27	68.63
Head (g)	45.60	45.80	50.00	54.60
Neck (g)	71.60^{b}	77.20^{ab}	77.80^{ab}	88.20^{a}
Wings (g)	113.60	133.00	111.20	131.60
Breast (g)	211.40^{ab}	218.00^{ab}	189.80^{b}	257.80^{a}
Back (g)	219.80	233.20	222.00	266.00
Thigh (g)	140.80^{ab}	141.80^{ab}	129.00^{b}	153.60^{a}
Drumstick (g)	121.20	131.80	123.00	139.80
Feet (g)	51.40	52.60	52.40	58.80

Means on the same row with different superscripts different significantly ($p < 0.05$). $^{a\,b\,c}$ means different superscripts in the same column different significantly ($p < 0.05$). Means on the same row with different superscripts are significantly different ($p < 0.05$). T1, T2, and T3 were commercial feeds bought from different commercial producers while diet T4 is a formulated diet serving as control dietary treatment. wt: Weight.

Table 5. The effects of different selected commercial grower feeds on internal organs' weights of *Isa brwon* pullet chickens

Parameters	T_1	T_2	T_3	T_4
Liver (g)	20.20^{ab}	18.20^{b}	19.80^{ab}	23.20^{a}
Kidney (g)	3.80^{ab}	5.20^{a}	5.20^{a}	3.40^{b}
Spleen (g)	2.80	2.20	2.20	2.80
Heart (g)	6.00	7.40	6.20	7.80
Proventriculus (g)	7.00	7.40	7.60	7.80
Gizzard (g)	46.80^{c}	50.40^{bc}	52.40^{ab}	55.20^{a}
Lungs (g)	8.20	7.00	8.20	9.00
Small intestine (mm)	116.80	107.80	105.60	107.60
Large Intestine (mm)	19.90	22.40	21.80	25.60
Crop (g)	7.20	9.40	8.60	7.20
Caeca (mm)	16.10	15.70	14.40	15.20
Duodenum loop (mm)	15.60	15.00	14.60	14.40
Abdominal fat (g)	29.60^{ab}	24.80^{ab}	30.40^{a}	7.80^{b}

Means on the same row with different superscripts are significantly different ($p < 0.05$), T1, T2, and T3 were commercial feeds bought from different commercial producers while diet T4 is a formulated diet serving as control dietary treatment, ^{a,b,c} means different superscripts in the same column differ significantly ($p < 0.05$).

CONCLUSION

The study indicated a self-formulated diet at the grower stage can replace the commercial poultry feeds used in the study. The farmers should attest that using a self-formulated diet at the grower stage would be cheaper and could also enhance the optimum performance and profitability. The replacement of a self-formulated diet with commercial feeds in the study did not cause any negative effect on growth performance, carcass yield, and internal organs.

DECLARATIONS

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Authors' contribution

No fund was assigned to the Authors. Seun Ayoola collected the samples and carried out the fieldwork and wrote the first draft. Anthony Ekeocha, Ademiju Adeolu Aganga, and Oluwadele Joshua Femi supervised the overall research, and statistical analysis and revised the draft and final script approved by the authors.

Competing interests

The authors declare that they have no competing interests.

Ethical considerations

Ethical issues including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been checked by the authors which command respect in Nigeria by the ethical committed monitory team.

REFERENCES

Akinola LF and Ekine OA (2018). Evaluation of commercial layer feeds and their impact on performance and egg quality. Nigerian Journal of Animal Science, 20(2): 222-231. DOI: https://www.doi.org/10.4314/tjas.v20i2

Alagawany M, Elnesr SS, Farag MR, Tiwari R, Yatoo MI, Karthik K, Michalak I, and Dhama K (2020). Nutritional significance of amino acids, vitamins and minerals as nutraceuticals in poultry production and health - a comprehensive review. The Veterinary Quarterly, 41(1): 1-29. DOI: https://www.doi.org/10.1080/01652176.2020.1857887

Apantaku SO (2006). Analysis of participation of farmers in participatory poultry production research in Lagos State, Nigeria. Livestock Research for Rural Development, 18: 1-12. DOI: https://www.doi.org/10.4236/JSS.2006.934134

Dobermann D, Swift JA, and Field LM (2017). Opportunities and hurdles of edible insects for food and feed. Nutrition Bulletin, 42(4): 293-308. DOI: https://www.doi.org/10.1111/nbu.122

Ekeocha AH and Afolabi KD (2012). Carcass characteristics of broilers fed mexican sunflower (*Tithonia diversifolia*) leaf meal-based diets. Report and Opinion, 4(9): 51-55. DOI: http://www.dx.doi.org/10.7537/marsroj040912.09

González-Alvarado JM, Jiménez-Moreno E, Lázaro R, and Mateos GG (2007). Effect of type of cereal, heat processing of the cereal, and inclusion of fiber in the diet on productive

performance and digestive traits of broilers. Poultry Science, 86(8): 1705-1715. DOI: https://www.doi.org/10.1093/ps/86.8.170

Gopi M, Purushothaman MR, Dhinesh Kumar R, Prabakar G, and Chandrasekaran D (2019). Ubiquinol supplementation on energy metabolism and oxidative stress in broiler chicken. Indian Journal of Animal Research, 4(54): 445-450. DOI: https://www.doi.org/10.18805/ijar.B-3523

Griffioen H, Booij T, and Doerr C (2020). Quality evaluation of cyber threat intelligence feeds. In Conti, M. et al. (eds) Applied Cryptography and Network Security: 18th International Conference, ACNS 2020, Rome, Italy, October 19-22, Springer, Cham, 277-296. DOI: https://www.doi.org/10.1007/978-3-030-57878-7 14.

Hussein AS, Cantor AH, Pescatore AJ, Gates RS, Burnham D, Ford MJ, and Paton ND (2001). Effect of low protein diets with amino acid supplementation on broiler growth. Journal of Applied Poultry Research, 10(4): 354-362. DOI: https://doi.org/10.1093/japr/10.4.354

Kalam MA, Alim MA, Shano S, Nayem MR, Badsha MR, Mamun MA, Hoque A, Tanzin AZ, Khan SA, Islam A et al. (2021). Knowledge, attitude, and practices on antimicrobial use and antimicrobial resistance among poultry drug and feed sellers in Bangladesh. Veterinary Sciences, 8(6): 111. DOI: https://www.doi.org/10.3390/vetsci8060111

Lee SA, Febery E, Mottram T, and Bedford MR (2021). Growth performance, real-time gizzard pH, and calcium solubility in the gut of broiler chickens is dependent on the interaction between dietary calcium concentration and limestone particle size. British Poultry Science, 62(6): 827-834. DOI: https://www.doi.org/10.1080/00071668.2021.1929840

Madhuri G, Swathi G, Radhakrishna P, and Nagalakshmi D (2020). Effect of replacement of antibiotics with probiotics on performance, carcass characteristics and nutrient retention in broilers fed with meat cum bone meal. Indian Journal of Animal Research, 12(54): 1565-1571. Available at: https://arccjournals.com/journal/indian-journal-of-animal-research/B-3915

Mudhunguyo A and Masama E (2015). Comparison of broiler chicken performance on different phase feeding programs. International Journal of Innovative Research and Development, 4(6): 404-408. Available at: http://www.internationaljournalcorner.com/index.php/ijird_ojs/issue/current

National Research Council (NRC) (1994). Nutrient requirements of poultry: Ninth revised edition. Washington, DC: The National Academies Press. DOI: https://www.doi.org/10.17226/2114.

Noblet J, Wu SB, and Choct M (2021). Methodologies for energy evaluation of pig and poultry feeds: A review. Animal Nutrition, 8: 185-203. DOI: https://www.doi.org/10.1016/j.aninu.2021.06.015

Popoola IO, Popoola OR, Adeyemi A, Ojeniyi O, Olaleru I, Oluwadele F, and Akinwumi E (2020). Overall performance, carcass yield, meat safety potentials and economic value of heat-stressed broilers fed diets with balanced electrolytes. Food and Nutrition Sciences, 11: 615-628. DOI: https://www.doi.org/10.4236/fns.2020.117044

Rubio AA (2018). Effects of Corn particle size and feed form on growth performance and carcass characteristics of broilers. Available at: https://www.etd.auburn.edu//handle/10415/6279

Sano Y, Kanbe H and Kihara M, (2021). Morphological changes of pyloric caeca and their relevancy to motility in laboratory-reared Kurosoi rockfish (Sebastes schlegelii Hilgendorf), using an in vitro assay method. Aquaculture, 539.736604. DOI: https://doi.org/10.1016/j.aquaculture.2021.736604

Sanusi M, Rabi A, Doma UD, and Haruna J (2015). Comparative effects of self-formulated and four commercial diets on the growth performance, carcass and haematological parameters of broiler finisher in the tropics. Sokoto Journal of Veterinary Science, 13(2): 14-19. DOI: https://www.doi.org/10.4314/sokjvs.v13i2.3

Sharma M (2019). Performance of different commercial layer feeds on egg. Journal of Krishi Vigyan, 7: 184-189. DOI: https://www.doi.org/10.5958/2349-4433.2019.00031.X.

Taylor RD and Jones GPD (2004). The incorporation of whole grain into pelleted broiler chicken diet. Gastrointestinal and digesta characteristics. British Poultry Science, 45: 237-246. DOI: https://www.doi.org/10.1080/00071660410001715849

Thirumalaisamy G, Muralidharan J, Senthilkumar S, Hema Sayee R, and Priyadharsini M (2019). Cost-effective feeding of poultry. International Journal of Environmental Science and Technology, 5: 3997-4005. Available at: https://www.ijset.net/journal/1410.pdf

Varastegani A and Dahlan I (2014). Influence of dietary fiber levels on feed utilization and growth performance in poultry. Journal of Animal Production Advances, 4(6): 422-429. Available at: http://psasir.upm.edu.my/id/eprint/34183/

Webster AB, Fletcher DL, and Savage SI (1996). Humane on-farm killing of spent hens. Journal of Applied Poultry Research, 5(2): 191-200. DOI: https://www.doi.org/10.1093/japr/5.2.191

Williams RB, Bushell AC, Répérant JM, Doy TG, Morgan JH, Shirley MW, Yvoré P, Carr MM, and Frémont F (1996). A survey of *Eimeria* species in commercially-reared chickens in France during1994. Avian Pathology, 25(1): 113-30. DOI: https://www.doi.org/10.1080/03079459608419125

Zhao T, Wang S, Zou X, Zhang H, Yan Y, Huo H, Wang Q, and Su C (2021). Synthesis and up-conversion luminescence properties of Ho3+-Yb3+ co-doped glass ceramics containing Sr3Gd (PO4)3. Optical Materials, 121: 111547. DOI: https://www.doi.org/10.1016/j.optmat.2021.111547