Blood Profile and Carcass Characteristics of Broiler Finishers Fed Exogenous Enzyme Feather Meal Based Diets

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Abstract

The need for animal protein consumption cannot be over-emphasized. Unfortunately, the cost of poultry production is on increase as a result of high cost of feed production, hence the need for search to alternative but cost-effective ingredients. The experiment was conducted to assess the blood profile and carcass characteristics of broiler finishers fed enzyme fortified feather meal for fish meal replacement. One hundred and fifty 4-weeks old chicks were randomly assigned to five treatment groups in a completely randomized design. Each treatment was replicated three times. Treatment 1 contained 0% enzyme fortified feather meal, while treatment 2, 3, 4, and 5 contained 1, 2, 3, and 4% levels of enzyme fortified feather meal, respectively. Each level of enzyme fortified feather meal was used to partially replace fish meal in the experimental diets, while treatment effects were assessed over the experimental period. At 10th week of feeding trial, blood samples were collected from three (3) birds from each replicate for blood profile analysis, and later slaughtered for carcass quality. Results obtained showed no significant difference (P>0.05) in the dressed weight and dressed percentages, while most of the cut parts, breast, thigh, shank and wing expressed in percentage of dressed weight differed significantly (P<0.05). Hematological index analysis (HB, PCV, RBC, MCV, ESR, MCH) differed significantly (P<0.05) and were improved in the enzyme fortified feather meal fed broilers, while MCHC did not differ significantly (P>0.05). Most WBC differentials, heterophil, lymphocytes, differed significantly (P<0.05). Monocytes and eosinophil were similar, while basophil showed no trace within treatment means. The values of the serum biochemistry were mostly similar (P>0.05) except for the globulin and cholesterol which significantly increased with increasing inclusion of enzyme fortified feather meal.

Keywords: blood profile, broiler finisher, carcass quality, fish meal, enzyme fortified feather meal.
Running title: Blood-profile and carcass characteristics of finishers

Profil Hématologique Et Caractéristiques De La Carcasse Des Terminaux De Poulet A Griller Alimentés Avec Des Diètes A Base De Farine De Plumes Enzymées

Résumé

Le besoin de consommation de protéines animales ne peut être surestimé. Malheureusement, le coût de la production avicole augmente en raison du coût élevé de la production d'aliments, d'où la nécessité de rechercher des ingrédients alternatifs mais rentables. L'expérience a été menée pour évaluer le profil sanguin et les caractéristiques de la carcasse des terminaux de poulet à griller nourris avec de la farine de plumes enrichie en enzymes comme remplacement de la farine de poisson. Cent cinquante poussins de 4 semaines ont été assignés au hasard à cinq groupes de traitement dans un design complètement randomisé. Chaque traitement a été répété trois fois. Le traitement 1 contenait 0 % de farine de plumes enrichie en enzymes, tandis que les traitements 2, 3, 4 et 5 contenaient respectivement 1, 2, 3 et 4 % de farine de plumes enrichie en enzymes. Chaque niveau de farine de plumes enrichie en enzymes a été utilisé pour remplacer partiellement la farine de poisson dans les diètes expérimentales, tandis que les effets des traitements ont été évalués pendant la période expérimentale. À la 10e semaine de l'essai d'alimentation, des échantillons de sang ont été prélevés sur trois oiseaux de chaque

répétition pour l'analyse du profil sanguin, puis abattus pour évaluer la qualité de la carcasse. Les résultats obtenus n'ont montré aucune différence significative (P>0.05) dans le poids habillé et les pourcentages habillés, tandis que la plupart des parties découpées, poitrine, cuisse, tarses et ailes exprimées en pourcentage du poids habillé différaient significativement (P<0.05). L'analyse des indices hématologiques (HB, PCV, RBC, MCV, ESR, MCH) a montré des différences significatives (P<0.05) et a été améliorée chez les poulet à griller nourris avec de la farine de plumes enrichie en enzymes, tandis que le MCHC n'a pas différé de manière significative (P>0.05). La plupart des différentiels de globules blancs, hétérophiles, lymphocytes, différaient significativement (P<0.05). Les monocytes et les éosinophiles étaient similaires, tandis que les basophiles ne montraient aucune trace dans les moyennes des traitements. Les valeurs de la biologie sérum étaient principalement similaires (P>0.05), sauf pour la globuline et le cholestérol qui ont augmenté significativement avec l'inclusion croissante de farine de plumes enrichie en enzymes.

Mots-clés : *profil sanguin, terminal de poulet à griller, qualité de la carcasse, farine de poisson, farine de plumes enrichie en enzymes.*

Introduction

Livestock production has improved tremendously due to improvements in nutrition, animal health, breeding and genetics (FAO, 2016). This has directly contributed to poultry meat and eggs being produced enough to bridge the gap between protein demand and supply, attributable to the availability of high yielding exotic poultry that are adaptable to different environments in the world (Ewubare and Ozar, 2018). Broilers are the most efficient farm animals in converting feedstuff and by-products into high quality animal protein within a short period (Aboki *et al.*, 2013). The high cost of poultry production has led to the search for alternative but cost-effective ingredients for the poultry and livestock. The efforts to reduce high cost of feed for livestock production have necessitated the recycling of animal wastes such as by-products into poultry feed (Alao *et al.*, 2017). Some of these ingredients are fit for animal consumption and not competed for by humans (Madubuike, 2012). They are found to successfully replace the major conventional feed resources in poultry and livestock production. Thus increased production of poultry appears to lie in the ability of farmers to replace the feed ingredients that are expensive and highly competed for with the cheaper but nutritionally sound unconventional feed resources which can yield similar results and at the same time be cost effective and without deleterious effects on the animals (Wagh *et al*., 2021).

Materials and methods

Study area: The study was carried out at the Poultry Unit of the Teaching and Research Farm, Imo State University, Owerri. Owerri lies between latitudes $5^0$35'N and $6^0$10'N and longitudes $6^0$40'E and $7^0$11'E and on an altitude of 90m, with a mean annual rainfall of 2500mm, a temperature ranges of 26.5 - 27.5^{0}C and a relative humidity range of 70 - 80%. The mean annual evapo-transpiration is greater than 1450mm.

Experimental materials: The feathers were sourced from commercial slaughter houses, washed and boiled with a batch cooker at internal pressure of 50-60Pa for 60-90 minutes (Tesfaye *et al.,* 2017) under high pressure until the resulting process of hydrolysis converts the feathers into a more soluble form. The feathers were washed, sun-dried and milled to produce feather meal.

Feed ingredients: Feed ingredients such as fish meal, yellow maize, soyabean meal, groundnut cake meal, bone meal, kernel meal, vitamin-premix, salt, DL-methionine-HCl and lysine were sourced from a reputable feed ingredients dealer.

Proximate analysis of the feather meal and fish meal were conducted as well as the mineral analysis and gross energy.

Experimental diets: Five experimental diets; T_1, T_2, T_3, T_4 and T_5 were formulated. T_1 which served as control treatment contained 0% enzyme fortified, while diets T_2, T_3, T_4 and T_5 contained 1.00, 2.00, 3.00 and 4.00% at 100g of Biozyme for 100kg weight of feed, respectively according to manufacturer's prescription. All other ingredients were measured out and mixed vigorously in order to obtain homogeneity (Table 1). The enzyme used in processing the feather meal in this study is Biozyme® (Pancrellpase). It is a combination of three enzymes; lipase, protease and amylase, which are normally produced by the pancrease and are important in the digestion of fats, proteins and sugar (Biozyme Manual, 2010).

Experimental birds: A total of one hundred and fifty 4-week old broiler chicks were used for the experiment. The chicks were divided into five treatment groups of 30 birds each. Each group was randomly assigned to one of the experimental diets in a completely randomized design and was further sub-divided into three replicates of 10 birds.

Management operations: Daily routine operations such as provision of feed and water, washing of the feeder and drinker, cleaning of the pen, and changing of the litters were carried out. Biosecurity was also ensured, while vaccination and medicare schedule of the Teaching and Research Farms were strictly followed.

Data collection

Biochemical and haematological assessment: At the end of the feeding trial, three birds were randomly selected from each replicate, making a total of nine birds per treatment for biochemical and haematological studies. Ten millilitres (10mL) of blood sample was collected from each of the bird through the wing vein with a 10mL sterile syringe. About 5mL of blood was put in bottles containing ethylene diamine tetra-acetic acid (EDTA) as an anti-coagulant and was used for the haematological assessment. The other 5mL of blood was put into a vial bottle (without anticoagulant) and was allowed to coagulate to produce sera used for serum biochemical analysis.

Packed cell volume (PCV) was determined by the procedure described by Ratiff and Halls (1973), while other haematological parameters were determined using the procedure described by Schalm *et al.* (1975).

Carcass characteristics: Three birds were randomly selected from each treatment (one per replicate) and used for evaluation of the carcass and internal organ weights. The birds were starved of feed but offered water overnight and then slaughtered by severing the jugular vein with sharp knife after they have been weighed. The birds were defeathered and eviscerated. The live weights and dressed weights were recorded and the internal organ (liver, kidney, head, gizzard) was weighed and expressed as percentage of live weights.

Data analysis: Data obtained were subjected to one-way analysis of variance using the analytical software statistical package for social sciences (SPSS, 2012). Means were separated using the Duncan Multiple Range Test as outlined by the same SPSS package.

Table 1: Ingredient composition of the experimental broiler finisher diets

	diets				
Ingredients	**T_1 (Control)**	**T_2 (1.00%)**	**T_3(2.00%)**	**T_4 (3.00%)**	**T_5(4.00%)**
Maize	59.00	59.00	59.00	59.00	59.00
Soyabean	16.00	16.00	16.00	16.00	16.00
Groundnut cake	9.00	9.00	9.00	9.00	9.00
Fish meal	4.00	3.00	2.00	1.00	0.00
Feather meal	0.00	1.00	2.00	3.00	4.00
Palm kernel cake	6.00	6.00	6.00	6.00	6.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Lime stone	2.00	2.00	2.00	2.00	2.00
Common salt	0.25	0.25	0.25	0.25	0.25
Vitamin/mineral premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Level of exogenous enzyme: 100g/100kg of feed across the treatment groups

Calculated nutrient content of the experimental feed analysis

Crude protein	20.48	20.53	20.58	20.62	20.67
Calcium	1.64	1.63	1.61	1.60	1.59
Phosphorus	0.93	0.92	0.90	0.89	0.88
Crude fibre	3.58	3.57	3.55	3.54	3.52
ME (Kcal. Kg)	2977.71	2987.42	2997.13	3006.84	3016.55

ME=metabolizable energy

Results and discussion

Proximate analysis of fish meal and feather meal is shown in table 2. The dry matter of fish meal was 94.06% and also higher than that of feather meal which was 90.75%. The fish meal had lower values of crude protein (55.93%) and crude fat (5.91%) than the feather meal with values of 60.44 and 20.79%, respectively. On the other hand, fish meal had higher values of crude fibre (1.84%), total ash (23.10%) and nitrogen free extract (8.80%) than the feather meal, with values of 0.32%, 7.31% and 4.21% respectively. Fish meal had lower moisture content (5.94%) compared to the feather meal (6.93%). The results also revealed that iron, calcium, phosphorus, magnesium, copper concentrations were higher in fish meal compared to the feather meal, while zinc was higher in feather meal than the fish meal.

Table 2: Proximate and mineral composition of fish meal and feather meal

Nutrients	**Values**	
	Fish meal	**Feather meal**
Dry matter (%)	94.06	90.75
Crude protein (%)	55.93	60.44
Crude fat (%)	5.91	20.79
Crude fibre (%)	1.84	0.32
Total ash (%)	23.10	7.31

Nitrogen free extract (%)	8.80	4.21
Metabolisable energy (Kcal/kg)	3085.35	4086.36
Mineral compositions		
Calcium (%)	6.09	1.87
Phosphorus (%)	3.05	0.71
Magnesium (%)	2.00	0.08
Iron Fe (%)	1.50	0.05
Copper cu (%)	3.70	0.001
Zinc (%)	0.003	0.012

Carcass and organ characteristics

Results of carcass characteristics of finisher broilers fed varying levels of enzyme fortified feather meal for fish meal replacement were presented on table 3. The dressed weight, dressed percentage, neck, heart, gizzard and liver weight percentages were not significantly different *(P>0.05*) between the enzyme fortified feather meal and the control. However, carcass cut parts like the thigh, breast, head, shank and wing weight percentages differed significantly (*P<0.05*) between treatment groups, and were mostly improved in all the birds fed enzyme fortified feather meal diets more than the control value. Birds on the test diet had remarkable thigh, breast, head and shank percentages compared with the control, while T_2 had the least wing, weight percentage. From the results, the replacement of fish meal for enzyme fortified feather meal in the experimental diet yielded better cut parts than the control. Studies have also reported that feeding with feather meal at different levels of inclusion have no deleterious effect on carcass and organ weights of broilers (Nakhash, 2008; Xavier *et al*., 2011; Hasni *et al*., 2014). Values obtained in this study is higher than range obtained by Opoola *et al.* (2022) on broiler finishers diet supplemented with vitamin C and zinc.

Table 3: Carcass analysis of finisher broilers fed enzyme fortified feather meal

[a,b] means on the same horizontal row with different superscripts are significantly different

Parameters	**T_1 (0.00%)**	**T_2 (1.00%)**	**T_3 (2.00%)**	**T_4 (3.00%)**	**T_5 (4.00%)**	**SEM**
Dress weight (g)	2735.05	2708.69	2723.03	2713.37	2668.44	1.86
Dressing (%)	84.96	84.45	85.07	85.94	85.32	0.25
Thigh %	15.35[b]	20.91[a]	20.98[a]	20.54[a]	20.40[a]	0.74
Breast %	27.67[b]	28.72[a]	28.52[a]	28.45[a]	28.22[ab]	0.12
Head %	3.46[b]	3.64[a]	3.61[a]	3.61[a]	3.58[a]	0.02
Shank %	4.38[b]	4.73[a]	4.71[a]	4.65[a]	4.65[a]	0.02
Neck %	5.75	5.85	5.79	5.73	5.72	0.02
Wing %	9.27[a]	8.67[b]	9.18[a]	9.18[a]	9.16[a]	0.05
Heart%	0.66	0.63	0.62	0.63	0.62	0.01
Gizzard %	3.37	3.32	3.25	3.24	3.21	0.03
Liver%	2.58	2.56	2.55	2.51	2.49	0.01

(P<0.05)

SEM: Standard Error of Mean

Haematological indices

Result on haematological indices of finisher broilers finisher fed enzyme fortified feather meal is presented on table 4. The indices include: Haemaglobin (Hb), Packed cell volume (PCV), Red blood cell (RBC), Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), Erythrocyte sedimentation rate (ESR), White blood cell (WBC), and its differentials.

The Hb, PCV, RBC, MCV, MCH, WBC, ESR lymphocytes and heterophils differed significantly *(P<0.05)* across the means, while eosinophils and monocytes were similar *(P>0.05*). Basinophil was not seen in any of the treatment groups.

The haematological indices of broilers in this study significantly improved with increasing inclusion of the test material in the diets. Haematological parameters are good indicators of the physiological status of animals (Khan and Zafar, 2005). Isaac *et al.* (2013) stated that animals with good blood composition are likely to show good performance, that the Hb and PCV concentration have the physiological function of transporting oxygen to the tissues of the animal for oxidation of ingested food so as to release energy for the body functions as well as transporting carbon dioxide out of the animal body. In this study, these blood indices were improved with increasing inclusion of enzyme fortified feather meal in the diets which suggests that enzyme fortified feather meal was neither deleterious nor caused allergic reactions in the experimental birds. The value obtained for Hb falls within the normal range (7-13 g/dL) for chickens. Also, the range of values obtained in all the parameters measured were within the normal reference range for chicken as earlier reported by Mitruka and Rawnsley (1997).

Table 4: Haematological indices of broiler finisher birds fed varying levels of enzyme fortified feather meal for fish meal replacement

Parameters	T_1(0.00 %)	T_2(1.00%)	T_3(2.00%)	T_4(3.00%)	T_5(4.00%)	SEM
Hb (g/dL)	12.41^{c}	13.40^{b}	13.56^{ab}	13.69^{ab}	13.86^{a}	0.14
PCV (%)	38.69^{c}	39.60^{b}	40.69^{a}	40.86^{a}	40.98^{a}	0.24
RBC ($X10^{12}$/L)	11.52^{c}	12.09^{b}	12.60^{a}	12.80^{a}	12.85^{a}	0.14
MCV (*fl*)	132.13^{b}	131.60^{b}	142.20^{a}	140.78^{a}	141.69^{a}	1.28
MCH (*pg*)	22.34^{a}	22.36^{a}	20.94^{b}	22.50^{a}	22.00^{a}	0.16
MCHC (g/dL)	30.53	30.27	30.67	30.38	30.28	0.20
ESR (mm^3/h)	31.47^{a}	27.00^{bc}	28.67^{b}	36.33^{a}	33.33^{ab}	1.76
WBC (X 10^9/L)	5.60^{c}	5.84^{bc}	6.35^{b}	7.14^{a}	7.21^{a}	0.18
Heterophil (%)	52.33^{ab}	53.00^{a}	52.67^{a}	51.33^{b}	52.00^{a}	0.44
Eosinophil (%)	1.33	1.67	1.33	1.67	1.67	0.13
Lymphocytes (%)	42.33^{ab}	41.50^{b}	44.67^{a}	41.33^{b}	43.33^{ab}	0.46
Basophils (%)	0.00	0.00	0.00	0.00	0.00	0.00
Monocytes (%)	1.33	1.67	1.33	1.33	1.33	0.13

$^{a.b.c}$ means on the same horizontal row with different superscripts are significantly different *(P<0.05).*

SEM: Standard Error of the mean.

Hb=Haemoglobin, PCV=Packed cell volume, RBC=Red blood cell, MCV=Mean corpuscular volume, MCH= Mean corpuscular haemoglobin, MCHC= Mean corpuscular haemoglobin concentration, ESR= Erythrocyte sedimentation rate, WBC= White blood cell

Serum biochemistry

Results of serum biochemistry of broiler finishers fed varying dietary levels of enzyme fortified feather meal for fish meal replacement is presented on table 5. With the exception of total protein albumin, cholesterol and glucose which were statistically similar *(P>0.05*), all other parameters differed significantly *(P<0.05)* within the treatment means. Most of the parameters (total serum protein, albumin, creatinine and urea) had similar values with the control. These parameters have been associated with the quality, quantity and availability of proteins in a diet (Iyayi and Tewe, 1998). The significant increase in globulin values of the enzyme fortified feather meal treated broilers over the control, suggests improved immunoglobulin production which will help defend the body against microbial invasion. The serum cholesterol of the experimental birds was also significantly higher than the control, while the glucose levels were decreased. However, the values obtained in this study fell within the reference range for chicken (Bamgbose *et al.,* 2007).

Table 5: Serum biochemistry of broiler finisher birds fed varying dietary levels of enzyme fortified feather meal for fish meal replacement

Parameters	T_1(0.0%)	T_2(1.0%)	T_3(2.0%)	T_4(3.0%)	T_5(4.0%)	SEM
Total protein (g/L)	75.33	75.40	75.51	75.59	75.65	0.05
Albumin (g/L)	21.57	21.73	24.96	21.61	21.63	0.69
Globulin (g/L)	54.74^{c}	55.48^{b}	55.58^{a}	55.62^{a}	55.63^{a}	0.09
Urea (mmol/L)	3.20	3.53	3.50	3.48	3.45	0.06
Creatinine (mmol/L)	50.67	52.00	51.00	51.00	51.67	0.25
Cholestrol (mmol/L)	25.40^{b}	30.73^{a}	30.91^{a}	31.18^{a}	30.67^{a}	0.75
Glucose (mmol/L)	33.81^{a}	33.55^{b}	33.06^{b}	33.59^{b}	33.61^{b}	0.03

^{a,b} Means on the same horizontal row with different superscripts are significantly different *(P<0.05).*

SEM: Standard Error of the mean.

Conclusion

In conclusion, the replacement of fish meal for enzyme fortified feather meal based diets yielded better cut parts while the blood indices improved with increasing inclusion of the test material which suggests that enzyme fortified feather meal based diet was neither deleterious nor caused allergic reactions in the experimental birds. Therefore, the use of this agro by-products in formulation of poultry feed will in turn reduce the cost of poultry feed.

References

Aboki, E., Jongur, A. A. and Onu, J. I. 2013. Productivity and technical efficiency of family poultry production in Kurmi Local Government Area of Taraba State, Nigeria. *Journal of Agriculture and Sustainability*, 4 (1):52-66.

Alao, B. O., Falowo, A. B., Chulayo, A. and Muchenje, V. 2017. The potential of animal by-products in food systems: Production, prospects and challenges. *Sustainability*, 9(7):1089.

AOAC 1995. *Official methods of analysis.* 16th edition, Association of Official Analytical Chemists, Washington DC, USA.

Bamgbose, A. M., Oso, A. O., Omikola, B. G., Agoola, A., Jegede, A. V.

(2007). Performance of finishing turkeys fed wheat based-diets. Proceedings of the 32nd Annual Conference of Nigerian Society for Animal Production, March 18th-21st, University of Calabar, Nigeria. Pp. 505-506.

Biozyme Manual, 2010. TOSAM (TIS) Integrated Services Ltd. Lagos, Nigeria.

Ewubare, D. B. and Ozar, V. 2018. Effect of poultry production on Agricultural production in Nigeria. *Economy*, 5(1): 8-16.

FAO, 2016. Livestock-related interventions during emergencies-The how-to-do-it manual. Edited by Philippe Ankers, Suzan Bishop, Simon Mack and Klass Dietze, *FAO Animal Production and Health Manual* No.18, Rome.

Hasni, M. S., Sahito, H. A., Memon, M. A., Sanjrani, M. I., Gopang, M. A. and Soomro, N. A. 2014. Effect of feeding various levels of feather meal as a replacement of fish meal on the growth of broiler. *International Journal of Agriculture, Innovations and Research*, 3(2), 505-511.

Isaac, L. J., Abah, G., Akpan, B., Ekaette, I. U. 2013. Haematological properties of different breeds and sexes of rabbits. Proceedings of the 18th Annual Conference of Animal Science Association of Nigeria, Pp: 24-27.

Iyayi, E. A. and Tewe, O. O. 1998. Serum total protein, urea and creatinine levels as indices of quality of cassava diets for pigs. *Trop. Vet.*, (16) 59-67.

Khan, T. A. and Zafar, F. 2005. Haematological study in response to varying doses of estrogen in broiler chicken. *International Journal of Poultry Science*, 4 (10): 748-751.

Madubuike, F.N. 2012. *Bridging animal protein supply and demand gap in Nigeria.* IMSU Owerri Inaugural lecture (serial 7). Imo-state University Press, Owerri.

Mitruka, H. M. and Rawnsley, S. K. 1997. *Chemical, biochemical and haematological reference values in normal experimental animals.* Masson Publishing, New York, USA. 287.

Nakhash, R. M. S. 2008. The effects of partial replacement of soybean meal in the grower diet with sun-dried blood and boiled feather meals on the performance of broiler chicks. Thesis for Master of Animal Production, Faculty of Graduate Studies, An-Najah National University Nablus, Palestine.

Opoola, E., Atte, P. O., Lawal, A. N., Oyebanji, O. A. and Olaniyan, G. 2022. Effects of vitamin C and zinc supplementation in drinking water on growth performance of broiler chickens reared in the tropics. *Nigerian Journal of Animal Science*, 24(3): 71-78.

Ratiff, C. R. and Halls, F. 1973. *Laboratory manual of clinical biochemistry.* Scotland White Memorial Hospital Publication Office Template, Tx

Schalm, O. W., Jain, N. C. and Carol, E. J. 1975. *Textbook of veterinary hematology.* 2nd edition, Lea and Febiger, Philadelphia.

SPSS 2012. Statistical Packages for Social Sciences, ver. 20.0, SPSS Inc. Illinois (USA).

Tesfaye, T., Sithole, B., Ramjugernath, D., Chunilall, V. 2017. Valorisation of chicken feathers. Characterisation of chemical properties. *Waste management*, 68: 626-635.

Wagh, H. A., Shinde, R. M., Banger, S. S., Gaharwar, A. M., Shingote, P.

R., Wasule, D. L., Gade, R. M., Shirsat, K. D., Borker, R. D., Madke, M., Pimpalzare, P. and Patange, V. V. 2021. Low cost feed formulation for economical rearing of rural poultry. *International Journal of Chemical Studies*, 9(1):260-263. Doi: https//doi.org/10.22271/chemi.2021.v9.ile.11661.

Xavier, S. A. G., Stringini, J. H., de Brito, A. B., Andrade, M. A., Café, M. B. and Leandro, N. S. M. 2011 Feather and blood meal in pre-starter and starter diets for broilers. *R. Bras. Zootec.*, 40(8): 1745-1752.

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