Agr. Foo. Nat. Res. J. Volume 3, Issue 1, Page 122 - 127

ISSN: 3043-5420

Agriculture, Food and Natural Resources Journal

The Official Journal of the Faculty of Agriculture, Nnamdi Azikiwe University, Nigeria

Journal homepage: https://journals.unizik.edu.ng/afnrj

Original Article

Effect of dietary inclusion of Tuber mushroom (*Pleurotus tuber-regium*) meal on growth performance of Broiler Birds

OPEN ACCESS

Ayisat Olayemi ADISA* & Cordelia Ifeyinwa EBENEBE

[1]*Department of Animal Science, Nnamdi Azikiwe University, Awka, Nigeria*

DOI: https://www.doi.org/10.5281/zenodo.13951165

Editor: *Dr Onyekachi Chukwu, Nnamdi Azikiwe University, NIGERIA*

Received: *February 7, 2024*
Accepted: *March 23, 2024*
Available online: *March 31, 2024*

Peer-review: *Externally peer-reviewed*

Conflict of Interest: The authors have no conflicts of interest to declare

Financial Disclosure: *The authors declared that this study has received no financial support*

ABSTRACT

This study evaluated the growth performance of broiler chickens fed diets containing varying levels of *Pleurotus tuber-regium* (PTR). A total of 120 broiler chicks were randomly assigned to four dietary treatments: T1 (control, no PTR), T2 (2.5% PTR), T3 (5.0% PTR), and T4 (7.5% PTR) in a completely randomized design for eight weeks. Each treatment had three replicates with 10 birds per replicate. Feed intake, weekly weight gain, and feed conversion ratio (FCR) were recorded, and data were analyzed using One-way analysis of variance (ANOVA) to determine the significant effects of the treatments on the response variables. Means were separated using Duncan's new multiple range test. Significant differences ($P<0.05$) were observed in body weight, weight gain, feed intake, and FCR among the experimental diets. The control group (T1) recorded the highest body weight (3.66 kg) and weight gain (2.16 kg). Inclusion of 2.5% PTR (T2) did not significantly affect weight gain compared to the control, while higher inclusion levels (T3, T4) reduced feed intake at certain weeks. T1 and T2 had the lowest FCR, indicating better feed efficiency. The study concluded that dietary inclusion of tuber mushrooms up to 2.5% posed no adverse effects on growth performance. It is recommended that 2.5% PTR can be safely included in broiler diets to maintain growth without compromising feed efficiency. Higher levels may reduce feed intake and should be further investigated.

K E Y W O R D S : *Broiler diet, Feed additive, Growth performance, Poultry nutrition*

INTRODUCTION

Nigeria is experiencing a significant protein deficiency, with a daily per capita intake of 45.4g—below the recommended 53.8g (Metu et al., 2016; Akerele et al., 2017; Protein Challenge, 2020). Efforts to address this issue has been hampered by challenges such as high feed costs, limited pasture land, disease incidence in livestock, and cultural and religious taboos regarding certain livestock, poultry farming, particularly broiler production, emerges as a promising solution due to its short generation interval, cost-effectiveness, and high nutritional value. Broiler chickens are an essential source of animal protein in Nigeria, with a protein content of 21-50% compared to other meat sources (FAO, 2008). However, feed costs pose a significant challenge to broiler production, accounting for up to 70% of the total expenditure (Thirumalaisamy et al., 2019; Moustafa, 2023). The search for alternative feed ingredients has led to the

*Corresponding author: ci.ebenebe@unizik.edu.ng; +2348033924529

exploration of locally available and affordable options, including mushrooms.

Mushrooms, as macro fungi, are a non-wood forest bio-resource (NWFR) known for their diverse nutritional, medicinal, and agricultural benefits (Osemwegie and Okhuoya, 2014). In Nigeria, these mushrooms are commonly sold during the rainy season, though knowledge of edible versus poisonous species remains limited across cultural contexts (Okhuoya et al., 2010; Kalu et al., 2013). Their low carbohydrate and lipid content make them suitable for weight management, and they provide significant energy (454g of fresh mushrooms yielding approximately 120 kilocalories). Notably, mushrooms have shown various health benefits, including antioxidant and immune-enhancing properties (Dalloul et al., 2006; Borchers et al., 2008; Garcia-Lafuentea et al., 2010), while also being effective in improving growth performance and feed conversion ratios in poultry (Mahfuz et al., 2019). Despite the known advantages, research specifically addressing the incorporation of tuber mushrooms in broiler diets is limited, underscoring the need for further investigation into their potential to improve growth performance and contribute to alleviating protein deficiencies in Nigeria. The objective of this study is therefore to assess the effect of dietary inclusion of tuber mushroom (*pleurotus tuber-regium*) meal on growth performance of broiler chickens.

MATERIALS AND METHOD

Experimental Site and Location

The experiment was conducted at the Animal Science Teaching and Research Farm Nnamdi Azikiwe University in Awka, Anambra state. Nnamdi Azikiwe university, Awka is located from latitude 6.245°N to 6.283°N and longitude 7.115°E to 7.121°E (Chukwu et al., 2020).

Processing of Test Ingredient *(Pleurotus tuber-regium)*

Tuber mushrooms *(Pleurotus tuber-regium*) were obtained from a popular market centre (Eke-Awka) within Awka Metropolis. The bulk purchased mushrooms were soaked overnight for easy grinding then properly blended into powder form using a commercial grinding machine and then oven dried with TT-9053 laboratory oven at 100 °C for 12 hours. The blended mushrooms were incorporated into the formulated diet: T1 (control, no PTR), T2 (2.5% PTR), T3 (5.0% PTR), and T4 (7.5% PTR)

Experimental birds and management

A total of one hundred and twenty (120) day old broiler chicks were sourced from Amo sieberer hatchery in Awe, Oyo state and were transported during the cool hours of the evening. The housing units comprise of four pens in a 6m by 2m house in such a way that each pen contain birds for a particular treatment. Each treatment consisting of 30 birds and was replicated three (3) times with ten (10) birds per replicate. Prior to the arrival of the chicks, the poultry house was fumigated, washed, disinfected and allowed to dry for seven days. The birds were vaccinated against disease. They were also given anti-stress preparations to enable the chicks recover from stress they may have passed through during transportation from the hatchery to the site of the experiment. Infections bursa disease vaccine was administered at the 7^{th}, 17^{th} and 27^{th} day respectively. Antibiotics and embazin-forte were also administered as at when due. Heat was supplied for brooding using a combination of kerosene lantern in each pen and a large size charcoal burner and the brooder house was well covered with polythene sheet. The litter was always replaced with wet to discourage the growth of pathogens. Bio-security and other important routine management practices were observed. The birds were reared on deep litter system. The feeding trial lasted for eight weeks (56 days). Feed and clean water was given to the birds.

Experimental Design

The experimental design used was completely randomized design (CRD). The statistical model for completely randomized design in given below:

$$Yij = \mu+Ti+T\ eij \quad (1)$$

Where Yij = Single Observation, μ = Overall Mean, Ti = Effect of the treatment and Eij = Experimental Error

Data collection

Chemical Analysis

The proximate composition and phytochemical analysis of tuber mushroom sclerotia were carried out at the Biochemistry Laboratory, Nnamdi Azikiwe University using the Official Methods of the Association of Official Analytical Chemists (AOCA 1999) method. Moisture content, Ash, crude fibre, total carbohydrates and crude protein were determined. Similarly, the following phytochemicals were screened according to standard methods of Usunobun et al, 2014; Tannins (mgTAE/g), Total phenols (mgGAE/g), Flavonoids (mgCAE/g) and Alkaloids (%).

Feed Intake and Weight

Feed intake was determined as the difference between weights of feed offered and weight of left over. This was measured on daily basis. Weekly record of weight was used to deduce the weekly weight gain.

Feed intake = weight of feed offered - weight of left over (1)

Weight gain = final weight - initial weight (2)

Feed conversion ratio = total quality of food consumed/weight gain (3)

Statistical Analysis

Data collected over the course of the experiment was subjected to the analysis of variance (ANOVA) using SPSS version 25 (2017) to determine the effects between treatments following the complete random design with three replications. Means were separated using Duncan's Multiple Range Test at a significant level of $p \leq 0.05$.

Table 1; Proximate Composition of *Pleurotus tuber-reguim*

Parameters	Value
Moisture (%)	38.25
Ash (%)	1.00
Fat (%)	11.6
Protein (%)	9.19
Fiber (%)	10.8
CHO (%)	29.16
Metabolisable energy (Kcal)	257.8

Table 2 Gross Composition of Feed Ingredients in the Formulated Starter Feed

INGREDIENTS (Kg)	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)
Maize	49	48	46.5	45.5
Full fat soya	24	24	24	24
Fish Meal	4	4	4	4
Wheat Offal	7	5.5	5.5	5
PKC	11	11	10	9
Bone Meal	3	3	3	3
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Broiler Premix	0.25	0.25	0.25	0.25
Toxin binder	1	1	1	1
Salt	0.25	0.25	0.25	0.25
Tuber mushroom	-	2.5	5.0	7.5
TOTAL	**100**	**100**	**100**	**100**
Crude protein	**22.05**	**22.07**	**22.12**	**21.84**
Metabolizalisable Energy (KCal/kg)	**2690.1**	**2686.9**	**2571.7**	**2512.8**

Table 3 Gross Composition of Feed Ingredients in the Formulated Finisher Feed

INGREDIENTS(Kg)	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)
Maize	50	49	48	47
Full Fat Soya	18	18	18	18
Fish Meal	4	4	4	4
Wheat Offal	12	10.5	10	9
PKC	11	11	10	9.5
Bone Meal	3	3	3	3
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Broiler Premix	0.25	0.25	0.25	0.25
Toxin binder	1	1	1	1
Salt	0.25	0.25	0.25	0.25
Tuber mushroom	-	2.5	5.0	7.5
TOTAL	**100**	**100**	**100**	**100**
Crude protein	**20.27**	**20.26**	**20.18**	**20.21**
Metabolizalisable Energy (KCal/kg)	**2629.1**	**2575.9**	**2517.1**	**2461.1**

RESULTS AND DISCUSSION

Results of Growth Performance of Broiler Chicken Fed Diet Containing *Pleurotus tuber-reguim* Based Diet Meal

Body Weight

Table 4 shows the weekly body weight of broiler birds fed diet containing *Pleurotus tuber-reguim* meal. From weeks 3 to 8, body weights significantly decreased with increasing levels of *Pleurotus tuber-regium* meal, with the control group and birds fed 2.5% Pleurotus tuber-regium (T2) exhibiting the highest weights, while those on 5.0% (T3) and 7.5% (T4) had notably lower weights, particularly the latter, which recorded the lowest at the finisher stage. The trend of decreasing body weights in broiler chickens with higher inclusion levels of Pleurotus tuber-regium (PTR) meal from weeks 3 to 8 aligns with previous findings in studies conducted on rats (Okolo et al. 2016; Adeyi et al. 2021). However, Salam et al., (2021) presented a different perspective, reporting improved growth performance in rabbits fed a diet containing 50.0 g/kg Pleurotus tuber-regium sclerotium powder (PTRSP). This group showed better live weight, weight gain, feed intake, and feed conversion ratio compared to rabbits on other dietary treatments containing 0.0, 25.0, and 75.0 g/kg PTRSP.

Table 4: Weekly Body Weight of Broiler Fed Diet Containing Varying Inclusion of PTR

PARAMETERS (kg)	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)	SME	P-VALUE
WEEK 1	0.104	0.102	0.103	0.102	0.001	0.39
WEEK 2	0.256	0.237	0.246	0.233	0.11	0.26
WEEK 3	0.563^{a}	0.562^{a}	0.411^{b}	0.342^{c}	0.013	0.00
WEEK 4	1.00^{a}	0.883^{b}	0.878^{b}	0.824^{b}	0.034	0.03
WEEK 5	1.45^{a}	1.22^{b}	1.14^{b}	1.14^{b}	0.059	0.019
WEEK 6	2.24^{a}	2.08^{b}	1.84^{b}	1.66^{b}	0.069	0.002
WEEK 7	2.95^{a}	2.69^{b}	2.38^{c}	2.32^{c}	0.046	0.00
WEEK 8	3.66^{a}	3.35^{b}	3.06^{c}	2.94^{d}	0.024	0.00

^{d}Means in the Same Row With Different Superscripts are Significantly Different ($P<0.05$), SEM = standard error of the mean P-value = probability value, T_1 = 0% dietary inclusion of tuber mushroom, T_2 = 2.5% dietary inclusion of tuber mushroom, T_3 = 5.0% dietary inclusion of tuber mushroom, T_4 = 7.5% dietary inclusion of tuber mushroom

Weekly Weight Gain

The weekly weight gains of broiler chicks fed diets containing varying inclusion level of tuber mushroom meal are shown in Table 5. At week 3, significant weight gain differences ($P < 0.05$) were noted, with T1 (0% PTR) and T2 (2.5% PTR) achieving higher gains (0.35 kg and 0.38 kg) than T3 (5.0% PTR) and T4 (7.5% PTR) (0.22 kg and 0.16 kg), and by week 5, T1 and T2 continued to show greater weight gain (0.79 kg and 0.71 kg) compared to T3 and T4, both at 0.48 kg. The lower weight gains observed in T3 (5.0% PTR) and T4 (7.5% PTR) (0.22 kg and 0.16 kg, respectively) could indicate that higher inclusion levels may reduce the overall nutrient density of the diet or introduce anti-nutritional factors that negatively affect growth (Adeyi et al. 2021).

Table 5: Weekly Weight Gain of Broiler Chicken Fed Diets Containing Varying Inclusion Level of Tuber Mushroom Meal

Parameters (kg)	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)	SME	P-value
Week1	0.05	0.05	0.05	0.05	0.001	0.83
Week 2	0.21	0.18	0.19	0.18	0.012	0.28
Week 3	0.35^{a}	0.38^{a}	0.22^{b}	0.16^{b}	0.019	0.00
Week 4	0.65	0.51	0.66	0.66	0.05	0.07
Week 5	0.79^{a}	0.71^{ab}	0.48^{b}	0.48^{b}	0.07	0.04
Week 6	1.44	1.36	1.26	1.19	0.09	0.33
Week 7	1.51	1.33	1.12	1.14	0.10	0.08
Week 8	2.16	2.02	1.87	1.57	0.16	0.13

$^{a-d}$Means in the Same Row With Different Superscripts are Significantly Different ($P<0.05$), SEM = standard error of the mean P-value = probability value, T_1 = 0% dietary inclusion of tuber mushroom, T_2 = 2.5% dietary inclusion of tuber mushroom, T_3 = 5.0% dietary inclusion of tuber mushroom, T_4 = 7.5% dietary inclusion of tuber mushroom

Feed Intake

The feed intake of broiler birds fed varying inclusion level of *Pleurotus tuber-regium* based diet meal is presented in Table 6. At Week 1, all groups had similar feed intake (1.03-1.04 kg), but by Week 2, T1 (0% PTR) and T3 (5.0% PTR) had higher intakes (3.21 kg and 3.16 kg) than T2 (2.5% PTR) and T4 (7.5% PTR) (3.04 kg and 3.12 kg), with significant differences observed at Week 3 where T1 and T2 had greater intake (5.18 kg and 5.24 kg) compared to T3 and T4 (4.60 kg and 4.04 kg); T1 consistently recorded the highest feed intake throughout the study, while the inclusion of *Pleurotus tuber-regium* meal at 5.0% and 7.5% significantly reduced feed intake during several weeks, with 2.5% inclusion not affecting intake compared to the control group. Decline in feed intake in broilers placed on diet 4 may suggest increasing dietary levels of anti-nutrients. Anti-nutrients have been reported to reduce feed acceptability by binding feed protein to the salivary gland and epithelium of the mouth (Yacout, 2016; Diribi Mijena and Fromsa Ijara, 2024).

Table 6: Feed Intake of Broiler Birds Fed Varying Inclusion Level of *Pleurotus tuber-regium* Based Diet

Parameters (Kg)	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)	SME	P-value
Week 1	1.03	1.04	1.03	1.03	0.005	0.38
Week 2	3.21^{a}	3.04^{c}	3.16^{ab}	3.12^{b}	0.23	0.05
Week 3	5.18^{a}	5.24^{a}	4.60^{ab}	4.04^{b}	0.20	0.009
Week 4	7.61	7.38	7.41	7.44	0.12	0.52
Week 5	9.58^{a}	8.54^{b}	8.65^{b}	8.41^{b}	0.16	0.004
Week 6	12.55^{a}	11.69^{b}	11.27^{b}	11.54^{b}	0.19	0.007
Week 7	13.66^{a}	13.40^{a}	12.79^{b}	12.42^{b}	0.17	0.003
Week 8	15.51	15.38	15.39	14.70	0.26	0.20

$^{a-d}$Means in the Same Row With Different Superscripts are Significantly Different (P<0.05), SEM = standard error of the mean P-value = probability value, T_1 = 0% dietary inclusion of tuber mushroom, T_2 = 2.5% dietary inclusion of tuber mushroom, T_3 = 5.0% dietary inclusion of tuber mushroom, T_4 = 7.5% dietary inclusion of tuber mushroom

Feed Conversion Ratio

Table 7 shows the feed conversion ratio of broiler birds fed varying inclusion of *Pleurotus tuber-regium* based diet meal. A significant difference (P < 0.05) in feed conversion ratio (FCR) was observed at Weeks 3 and 5, with T4 (7.5% PTR) exhibiting the highest FCR values (2.50 and 2.19, respectively), significantly differing from T1 (0% PTR) and T2 (2.5% PTR), while T3 (5.0% PTR) also showed higher FCR numerically, and overall, the inclusion of 2.5% PTR meal did not affect FCR compared to the control group, whereas higher inclusions of 5.0% and 7.5% PTR decreased feed efficiency, with the control group generally showing the lowest FCR and best feed efficiency. Salam et al,. (2021) reported a positive impact of *Pleurotus tuber-regium* inclusion at moderate levels in rabbit diets, with improved feed efficiency observed at 50 g/kg inclusion. This suggests that while moderate levels of PTR can enhance performance, exceeding optimal inclusion levels may lead to diminishing returns in terms of feed conversion efficiency as observed in the present study.

Table 7: Feed Conversion Ratio of broiler birds fed varying inclusion of Pleurotus tuber-regium based diet

Parameters (Kg)	T_1 (0%)	T_2 (2.5%)	T_3 (5.0%)	T_4 (7.5%)	SME	P-value
Week 1	1.88	1.91	1.93	1.90	0.03	0.69
Week 2	1.58	1.73	1.71	1.74	0.07	0.37
Week 3	1.57^{c}	1.61^{c}	2.11^{b}	2.50^{a}	0.10	0.001
Week 4	1.46	1.63	1.41	1.37	0.082	0.20
Week 5	1.53^{c}	1.56^{bc}	2.09^{ab}	2.19^{a}	0.17	0.04
Week 6	1.25	1.23	1.26	1.30	0.07	0.94
Week 7	1.30	1.46	1.44	1.51	0.09	0.51
Week 8	1.20	1.15	1.18	1.40	0.14	0.73

$^{a-d}$Means in the Same Row With Different Superscripts are Significantly Different (P<0.05), SEM = standard error of the mean P-value = probability value, T_1 = 0% dietary inclusion of tuber mushroom, T_2 = 2.5% dietary inclusion of tuber mushroom, T_3 = 5.0% dietary inclusion of tuber mushroom, T_4 = 7.5% dietary inclusion of tuber mushroom

CONCLUSION AND RECOMMENDATIONS

In conclusion, based on the current research findings, dietary inclusion of *Pleurotus tuber-regium* up to 2.5% pose no effect on growth performance and It is recommended that 2.5% PTR can be safely included in broiler diets to maintain growth without compromising feed efficiency and should be further investigated.

Acknowledgement

We would like to express our deepest gratitude to God Almighty for granting us the wisdom, knowledge, and strength to successfully complete this project. Finally, we would like to acknowledge the financial support from Alhaji Azeez Oladotun Bello of blessed memory and his wife Alhaja Moriam O. Bello, which made this research possible.

Authors' Contribution:

All authors contributed to the study conception and design. AOA: Writing, material preparation, data collection and analysis. CIE: Supervision; Validation; Visualization; Writing- review and editing. All authors read and approved the final manuscript.

Ethics Committee Approval: No Ethical issues.

REFERENCES

Aderolu A. Z, Lawal M. O, Aarode O. O & Seriki B. M (2015). Substitution Effects of Pleurotus tuber-regium Sclerotium for Soymeal on Growth, Nutrient Utilisation, Haematology and Carcass Composition of Juvenile African Catfish, *Clarias gariepinus Journal of Scientific Research and Development* 15(2): 42-46. https://ir.unilag.edu.ng/handle/123456789/6928

Aderolu, A. Z. & Oyedokun, G. T. (2008). Comparative Utilisation of Biodegraded Rice Husk in the Diets of Clarias gariepinus. *Journal of Fisheries and Aquatic Science*, 3(5): 312-319. https://doi.org/10.3923/jfas.2008.312.319

Adeyi, A.O., Adams, F.A. and Adenipekun, C.O. Pleurotus tuber-regium inclusion in diet ameliorates dyslipidaemia in obese-type 2 diabetic rats. *International Journal of Phytomedicine and Phytotherapy* 7, 84 (2021). https://doi.org/10.1186/s40816-021-00321-0

Akerele D., Sanusi R. A., Fadare O. A. & Ashaolu O. F. (2017): Factors influencing nutritional adequacy among rural households in Nigeria: How Does Dietary Diversity Stand among Influencers? *Ecology of Food and Nutrition* ,56: 187–203. https://doi.org/10.1080/03670244.2017.1281127

Borchers, A. T., Krishnamurthy, A., Keen, C. L., Meyers, F. J., & Gershwin, M. E. (2008). The immunobiology of mushrooms. *Experimental biology and medicine* 233(3), 259–276. https://doi.org/10.3181/0708-MR-227

Chukwu, O., Ezenwenyi, J.U. & Kenechukwu, T.V. (Checklist and Abundance of Open Grown Medico-Ethnoforest Tree Species in Nnamdi Azikiwe University, Awka, Nigeria. *Asian Journal of Biological Sciences*. 13(1):105-112. http://dx.doi.org/10.3923/ajbs.2020.105.112

Dalloul, R. A., & Lillehoj, H. S. (2006). Poultry coccidiosis: Recent advancements in control measures and vaccine development. *Expert Review of Vaccines*, 5(5), 657-667. https://doi.org/10.1586/14760584.5.1.143

Diribi Mijena and Fromsa Ijara (2024), Livestock Feed Anti-Nutritional Components: A Review, *Journal of. Nutrition and Food Processing, 7(6)*; https://doi.org/10.31579/2637-8914/231

FAO (2008). Food and Agriculture Organization of the United Nations. Mushroom production. https://www.fao.org/4/ab497e/ab497e00.htm

Garcia-Lafuentea, Ana & Moro, Carlos & Villares, Ana & Guillamón, Eva & Rostagno, Mauricio & D'Arrigo, Matilde & Alfredo, Martinez. (2010). Mushrooms as a Source of Anti-Inflammatory Agents. *Anti-Inflammatory & Anti-Allergy Agents in Medicinal Chemistry* 9. 125-141. https://doi.org/10.2174/187152310791110643

Kalu I.G., Nwachukwu,C.U., Ijeoma, B.C and Evans-Kemka,C.I. (2013). Problems facing mushroom availability and consumption in Owerri municipal council of Imo State, Nigeria. *Journal of Biology, Agriculture and Healthcare* 3(8):113-117. https://www.iiste.org/Journals/index.php/JBAH/article/view/6732

Mahfuz, S., He, T., Liu, S., Wu, D., Long, S., & Piao, X. (2019). Dietary Inclusion of Mushroom (Flammulina velutipes) Stem Waste on Growth Performance, Antibody Response, Immune Status, and Serum Cholesterol in Broiler Chickens. *Animals* 9(9), 692. https://doi.org/10.3390/ani9090692

Metu A. G., Okeyika K. O., Maduka O. D. (2016): Achieving sustainable food security in Nigeria: Challenges and way forward. 3rd International Conference on African Development Issues (CUICADI 2016). pp182-187 Retrieved from http://eprints.covenantuniversity.edu.ng/6653/1/icadi16

Moustafa M Metwally. "Broiler Chicken Feeds Cost Optimization using Linear Programming Technique under Egyptian Conditions". *Acta Scientific Veterinary Sciences* 57: 53-63. https://doi.org/10.31080/ASVS.2023.05.0688

Okhuoya, J.A., Akpaja, E.O., Osemwegie, O.O., Oghenekaro, A.O., & Ihayere, C. A. (2010). Nigerian mushrooms: Underutilized non-wood forest resources. *Journal of Applied Sciences and Environmental Management*.14(1): 43 – 54. https://doi.org/10.4314/jasem.v14i1.56488

Okolo, K. & Siminialayi, I. & Orisakwe, O.. (2016). Protective Effects of Pleurotus tuber-regium on Carbon- Tetrachloride Induced Testicular Injury in Sprague Dawley Rats. *Frontiers in Pharmacology. 7, 480.* https://doi.org/10.3389/fphar.2016.00480

Osemwegie, O.O & Okhuoya,J.A. (2014). Eco-diversity mushrooms in rubber plantations and a lowland forest. LAP Lambert Academic Publishing, Germany. 200 pp. https://eprints.lmu.edu.ng/id/eprint/163

Protein Challenge (2020): Nigeria Protein Deficiency Survey Report 2019. https://proteinchallengeng.com/protein-deficiency-report-2019/

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

Yacout M.H.M. Anti-nutritional factors & its roles in animal nutrition. *Journal of Dairy, Veterinary and Animal Research* 2016;4(1):237-239. https://doi.org/10.15406/jdvar.2016.04.00107