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Original Article

Effect of mushroom powder supplementation on the growth performance and carcass yield of broiler chicken

OPEN ACCESS

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ABSTRACT

The study was conducted to investigate the effect of varying inclusion levels of mushroom (Pleurotus ostreatus) meal on the growth performance and carcass characteristics of broiler chicken. One-hundred-and-twenty-Ross 308-day-old broiler chicks were randomly assigned to 4 dietary treatments with 30 birds per treatment. A treatment had 3 replicates with 10 birds per replicate. Mushroom powder (MP) was included at varying levels (0, 1, 1.5, 2%) in the formulated starter and finisher diets fed to the birds for 8 weeks, the duration of the experiment. Feed intake, body weight, carcass characteristics (thigh, wing, drumstick, shank, head, neck, gizzard, liver, heart, defeathered weight, carcass weight, and dressing %) were monitored during and at the end of the study, The data collected were subjected to analysis of variance. Treatment means were compared at a 5% probability level using Fisher's least Significant difference. Proximate analysis showed that the crude protein, fibre, ether extract, and metabolizable energy are within the nutritional requirements of the studied birds, indicating that it is a highly nutritious feed ingredient. The total feed intake was significantly ($P < 0.05$) influenced by the dietary treatment with broilers fed at a 2% inclusion level of MP recording the highest value compared to the other treatment groups. Dietary treatment had no significant effect on the weight gain of the birds. Supplementing with mushroom powder significantly influenced the carcass yield and organ weight of broiler chicken, with the highest values ($P<0.05$) record at 2% inclusion level. Mushroom powder can therefore be included in broiler diets at a 2% inclusion level for optimal performance. Broiler farmers can also incorporate mushroom powder into broiler diets.

KEYWORDS: *Carcass yield, Feed intake, Growth performance, Mushroom meal*

INTRODUCTION

Globally, the poultry industry is very pivotal in meeting the protein needs of the ever-growing human populations (Anosike *et al.,* 2018). According to Nwagu, (2002), 25% of the local meat production is from the poultry industry. Among the various poultry products, broiler chickens are particularly valued for their rapid growth rates and high feed conversion efficiency, making them indispensable in both commercial and subsistence farming systems (Anosike *et al.,* 2018). Feed which makes up an integral input is also a determining factor in the profit margin in the industry (Kalia *et al.*, 2017; Sugiharto & Ranjitkar, 2019; Mohammed & Worku, 2019). Afolayan *et al,* (2022) and FAO, (2023) reported that 60-75% of the total cost of production comes from feed. The sustainability and efficiency of broiler production are continually challenged by the need for cost-effective and nutritionally balanced feed ingredients (Mahfuz *et al.,* 2020). This necessitates invention of

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innovative feed solutions that will allow for efficiency and augment poultry productivity. This has prompted researchers to explore alternative feed additives (antibiotics, probiotics, organic acids, essential oils, prebiotics, enzymes, *etc*) that are sustainable, economically sustainable and helps in improving the efficiency of feed utilization thereby reducing the high cost of feed (Karangiya *et al.,* 2016; Ravindran, 2021).

Among alternative feed additives, mushrooms and mushroom by-products have gained considerable research focus due to their nutritional constituents and functional bioactive compounds (Elsayed *et al.,* 2021; Adebayo *et al.,* 2021). Mushroom meal contains moderate levels of crude protein, minerals, fibre, and essential amino acids, in addition to bioactive polysaccharides, phenolics, and β-glucans with antioxidant, antimicrobial, and immunomodulatory properties (Jayachandran *et al.,* 2017; Alharthi *et al.,* 2022). These characteristics make mushroom meal a potential dual-purpose feed ingredient, serving both as a nutrient source and a natural growth-promoting additive.

Recent studies by Kim *et al.* (2024) reported that up to 3% mushroom stump waste could be incorporated into broiler diets without compromising growth performance or amino acid digestibility. Wu *et al*. (2021) demonstrated that mushroom supplementation improved lipid metabolism and immune responses in broilers, while Wang *et al.* (2019) found improved feed efficiency and weight gain. Moreover, Willis *et al.* (2013) highlighted that mushroom inclusion reduced the incidence of coccidial infection in floor-reared broilers, further underscoring its health benefits. However, inclusion of mushroom in the diet of broilers and layers are not common in Nigerian livestock industry and therefore scarce in literature.

MATERIALS AND METHOD

The study was conducted at the Poultry Section of the Animal Science Teaching and Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. Awka lies within the Guinea Savanna zone (latitude 6.25°–6.28′ N and longitude 7.00°–7.08′ E) with an elevation of about 300 m above sea level, annual rainfall of 1,000–1,500 mm, and a mean daily maximum temperature of 27 °C (Abajue & Ewuim, 2018).

Oyster mushroom (*Pleurotus ostreatus*) was cultured on sorghum grains enriched with rice bran and $CaCO_3$, sterilized at 121 °C for 30 minutes, and inoculated with pure mycelium obtained from a local farm. Fruiting substrates were prepared with sawdust, rice bran, and $CaCO_3$, sterilized at 100 °C for 4 hours, they were inoculated with mushroom spawn, sprinkled with water daily and and incubated under 80% relative humidity for 6 weeks. Mature mushrooms were harvested, oven-dried at 80 °C for 3 h, milled, and stored for diet formulation.

A total of 120-day-old Ross 308 broiler chicks were obtained from Amo Hatchery, Ibadan. On arrival, the chicks were weighed and randomly allotted to four dietary treatments comprising of 0% (Treatment 1), 1.00% (Treatment 2), 1.50% (Treatment 3) and 2.00% (Treatment 4) of mushroom powder. Each treatment was replicated three times with 10 chicks per replicate in a completely randomized design. Birds were brooded for two weeks and reared under standard management with water and feed supplied *ad libitum*. The experimental diets were formulated to contain 23% crude protein (starter) and 20% crude protein (finisher). The trial lasted for 8 weeks.

Feed intake was calculated by the difference between feed supply and feed left over in each pen daily. Weight gain was determined as the difference between the weight of the animal at the beginning of the experiment and at weekly intervals. The feed conversion ratio was calculated as the ratio of total feed intake (kg) and total weight gain (kg) within each week for each treatment group. At the end of the experiment, three birds per replicate were randomly picked, fasted for 12 hours, slaughtered according to the method described by Olanrewaju *et al.* (2020) to evaluate carcass yield, dressing percentage.

$$Carcass\ Yield = Live\ Weight - (\ Feathers + Head + Feet + Viscera + Blood) \quad (1)$$

$$Dressing\ \% = \frac{Dressed\ weight}{Live\ weight}\ X\ 100 \quad (2)$$

The thigh, wing, drumstick, shank, head, neck, gizzard and liver were cut and weighed. Proximate composition of mushroom meal and diet were analyzed according to AOAC (2012), and metabolizable (ME) energy was determined by the Pauzenga equation (Pauzenga, 1985):

$$\text{ME (kcal/kg)} = 37\times\%CP + 81.1\times\%EE + 35.5\times\%NFE \quad (3)$$

Data collected were subjected to analysis of variance (ANOVA) using SAS (2023), and treatment means were separated using Fisher's Least Significant Difference test at a 5% level of significance.

RESULTS AND DISCUSSION

Proximate Composition of Mushroom Meal

The proximate composition of Mushroom powder is presented in Table1. The crude protein (CP)content of the mushroom powder demonstrates that mushrooms are a moderately rich protein source. The observed value is consistent with earlier reports by Alabi *et al.* (2021), who documented CP values of 20–25% for various mushroom species, indicating that mushrooms may serve as a partial but not complete substitute for high-protein ingredients. Importantly, mushroom protein is known to contain essential amino acids such as lysine and methionine which are limiting in cereal grains in appreciable amounts. (Chang & Miles, 2004). Thus, its inclusion in poultry diets could contribute to improving protein quality balance.

Table1: Proximate Composition of Mushroom Powder

Parameters (%)	Mushroom Powder
Moisture	18.25 ± 0.25
Crude Protein	24.70 ± 3.51
Ether Extract (Fat)	1.41 ± 0.90
Crude Fibre	8.00 ± 0.60
Ash	7.50 ± 0.00
Nitrogen-Free Extract (Carbohydrate)	40.14 ± 3.21
*Metabolisable Energy (kcal/g)	2454.21 ± 2.69

**ME = (37 × Crude Protein) + (81.8 × Crude fat) + (35.5 × NFE)*

The low ether extract value obtained indicates that mushroom powder is not a significant source of dietary fat. This agrees with the findings of Oyetayo & Ariyo (2013**)**, who observed low fat levels (1–3%) in edible mushrooms, attributing this to their natural composition. The low-fat content implies that mushroom powder contributes little to the energy density of diets compared to oilseeds such as groundnut cake. However, this characteristic also makes mushroom powder useful in reducing the risk of excessive dietary fat deposition in poultry and could contribute to lean meat production.

The crude fibre content was 8.00%, higher than that of conventional broiler feed ingredients like maize (~2%) and soybean meal (~6%) (NRC, 1994). Mushrooms are known to be rich in non-starch polysaccharides, including chitin, which contribute to fibre content (Onyimonyi *et al.,* 2009). While its high fibre content may reduce nutrient digestibility in monogastrics, moderate inclusion has been reported to improve gut health by stimulating microbial activity and intestinal motility (Sogunle *et al.,* 2019). Therefore, while mushroom powder fibre content may limit its level of inclusion in poultry diets, its gut-health-promoting role cannot be overlooked.

The estimated metabolisable energy (ME) of mushroom powder observed in this study was 2454.21 kcal/g. This value is lower than the ME of maize (3300–3400 kcal/kg) and soybean meal (2500–2700 kcal/kg) (NRC, 1994). Similar ME ranges for mushroom-based feeds have been reported by Olabode *et al.* (2020), who noted ME values between 2400–2600 kcal/kg. This indicates that while mushroom meal can contribute to the energy pool of the diet, it cannot be relied upon as a major energy source. However, when used in combination with higher energy ingredients, it can enhance dietary balance.

Ingredient Composition and Chemical Composition of Experimental Diet.

The ingredient composition and chemical composition of the experimental diet is presented in Table 2. The high DM values indicate that the diets were sufficiently concentrated to support efficient nutrient utilization, consistent with A.O.A.C. (2012) standards for poultry feeds.

The crude protein content of the starter diet aligns with NRC (1994) recommendations of 22–23% CP for broiler starters and 19–20% for finishers. The slight reduction in CP with increasing mushroom meal inclusion may be due to the relatively moderate protein content of mushrooms compared to soybean meal (Alabi *et al.,* 2021). Nonetheless, the diets met the protein requirements of broilers, indicating that partial substitution with mushroom meal can maintain optimal CP levels, which corroborates the results of Olabode *et al.* (2020), who reported that mushroom-incorporated broiler diets sustained protein adequacy without negatively impacting growth.

Higher fibre levels in finisher diets, particularly in T2 and T4, reflect the fibrous nature of mushrooms. Excess fibre may reduce nutrient digestibility, but moderate levels can improve gut health by stimulating microbial activity (Sogunle *et al.,* 2019). The values observed in this study remain within acceptable limits (<5%) for broiler diets, as recommended by Olawumi & Fajemisin (2019), suggesting that mushroom inclusion did not compromise nutrient digestibility.

Ether extract increased with mushroom inclusion, particularly in T3 starter diets (6.13%) and T2 finisher diets (5.50%). Mushrooms contain appreciable amounts of essential fatty acids, which contribute to energy density (Adejumo & Ologhobo, 2014). The values of the metabolizable energy are consistent with NRC (1994) recommendations (2800–3000 Kcal/kg for starters and 2900–3200 Kcal/kg for finishers). The relatively stable ME across treatments indicates that mushroom inclusion contributed to maintaining energy density, possibly through its carbohydrate and ether extract fractions.

Carbohydrates decreased slightly with higher mushroom inclusion, reflecting the replacement of cereal-based components with mushroom meal. Nevertheless, the carbohydrate content was adequate to meet broiler energy requirements (Adeyeye *et al.,* 2019).

Overall, the chemical composition of the experimental diets shows that mushroom powder compares well with NRC (1994) standards, and can be incorporated into broiler starter and finisher diets without compromising nutrient adequacy.

Growth Performance of Broiler Chicks Fed Varying Levels of Mushroom Powder

The growth performance of broiler chicks fed the experimental diet is shown in Table 3. The inclusion of mushroom powder up to 2% in broiler diets did not significantly (P> 0.05) affect total weight gain, average daily weight gain, or feed conversion ratio, although a slight but significant (P<0.05) increase in feed intake was observed. Similar neutral responses were reported when Hassan *et al.*(2020) included mushroom waste at 2% level in broiler chickens. Unlike this study, Willis *et al.* (2013) demonstrated that chickens displayed a marked surge in body weight using 5% oyster mushroom feed as a supplement. While mushroom powder recorded no significant difference in body weights in this study, Toghyani *et al.* (2012) reported a decreased body weight in chicken fed mushroom supplemented feed at 2% inclusion level.

Table 2. Ingredient Composition of Starter and Finisher Diet

Ingredient (kg)	Starter				Finisher			
	T1	T2	T3	T4	T1	T2	T3	T4
Maize	55.00	54.00	53.50	53.00	60.00	60.00	59.50	59.00
Soybeans Meal	24.00	24.00	24.00	24.00	18.00	18.00	18.00	18.00
Fishmeal	4.00	4.00	4.00	4.00	3.00	3.00	3.00	3.00
Mushroom Meal	0.00	1.00	1.50	2.00	0.00	1.00	1.50	2.00
Wheat Bran	3.00	3.00	3.00	3.00	5.00	4.00	4.00	4.00
Bone Meal	2.00	2.00	2.00	2.00.	2.00	2.00	2.00	2.00
Groundnut Cake	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Toxin Binder	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vitamin Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100
Calculated Analysis								
Crude Protein (%)	23.36	23.32	23.29	23.27	20.57	20.54	20.52	20.50
Metabolizable Energy	2921	2918	2915	2913	2940	2937	2935	2931
Chemical Composition of Experimental Diet								
Total carbohydrate	58.23	58.30	54.02	54.25	59.19	58.51	55.51	58.10
Dry Matter	92.25	90.25	88.75	87.50	90.25	91.75	86.75	91.00
Crude Protein	23.06	22.97	22.95	22.93	20.44	20.36	20.36	20.27
Crude Fibre	3.60	2.60	2.90	2.60	3.55	4.50	3.95	4.50
Ether Extract	4.61	4.38	6.13	5.25	4.47	5.50	4.13	5.38
Moisture	7.75	9.75	11.25	12.50	9.75	8.25	13.25	9.00
Ash	2.75	2.00	2.75	2.47	2.60	2.88	2.80	2.75
ME(Kcal/g)	2879.25	2864.48	2849.03	2977.85	2973.23	2965.50	2963.83	2945.88

T1= Treatment 1, T2= Treatment, T3=Treatment 3, T4= Treatment 4

Table 3. Growth Performance of Broiler Chicks Fed Varying Levels of Mushroom Powder

Parameters	T1	T2	T3	T4	SEM	LOS
Initial Weight (g)	0.042	0.042	0.042	0.042	0.00	NS
Final Weight (kg)	3.572	3.478	3.493	3.572	0.080	NS
Total Weight Gain (kg)	3.530	3.436	3.451	3.530	0.080	NS
Avg. Daily Weight Gain (kg/d)	0.071	0.069	0.069	0.071	0.002	NS
Total Feed Intake (kg)	7.973^d	8.002^c	8.030^b	8.058^a	0.009	*
Avg. Daily Feed Intake (g/d)	159.00	160.00	161.00	161.00	0.200	NS
FCR	2.26	2.33	2.33	2.28	0.050	NS

^{abcd} *Mean values with different superscripts within the row differed significantly; SEM= Standard Error of Mean; LOS= Level of Significance; * Significant at 0.05; NS= Not Significant.*

The increased feed intake observed in birds receiving mushroom powder may be attributed to the presence of oligosaccharides in the cell walls of mushrooms (Roy & Fahim, 2019). They could have influenced the equilibrium of the intestinal tract microflora positively by functioning as growth stimulators and prebiotics (Chou *et al.,* 2013). Baptista *et al.*(2023) reported that the palatability of mushroom-containing diets (pleasant umami flavors) can increase intake. Conversely, other studies have shown positive effects on weight gain and feed efficiency when concentrated mushroom extracts or higher inclusion levels were applied, likely due to bioactive compounds such as β-glucans and phenolics that modulate immunity and gut health (Wu *et al.,* 2021; Suberu *et al.,* 2024).

Overall, the present findings indicate that oyster mushroom powder at up to 2% dietary inclusion increased feed intake of broiler birds. However, higher inclusion rates, concentrated extracts, or functional assays may be necessary to fully exploit the growth-promoting and health-enhancing potential of mushroom-derived feed resources.

Carcass Yield, Cut-Parts and Organ Weight Measurements of Broiler Chicks Fed Varying Levels of Mushroom Powder

Table 4 shows the carcass yield, cut-parts and organ weight measurements of broiler chicks fed varying levels of mushroom powder. The result of the carcass yield, cut-parts and organ weight demonstrated that the dietary treatment had significant (P<0.05) impact on the measured parameters.

Treatments were significant on thigh, drumstick, wing, shank, neck, heart, liver, gizzard, defeathered weight, carcass weight and dressing%, with the highest value recorded in birds supplemented with mushroom powder at 2%. The significant increases in thigh, drumstick, wing, defeathered and carcass weights in T4 indicate that inclusion of *Pleurotus* spp. powder at 2% supported muscle accretion in major commercial cuts without altering overall carcass yield proportion (dressing %). Such selective improvement in cut-part masses with unchanged dressing percent is consistent with the reports of Olabode *et al.* (2020); Nasir *et al.* (2023) were low moderate inclusion of mushroom products and stem residues respectively, slightly enhanced muscle deposition.

Biologically, these observed increases in the thigh, drumstick, wing, defeathered and carcass weights at the highest inclusion may reflect modest improvements in nutrient utilisation or the influence of mushroom bioactives (e.g. β-glucans, polysaccharides, phenolics) on metabolism, gut health and nutrient partitioning towards muscle deposition (Jayachandran *et al.,* 2017; Willis *et al.,* 2013). The small rises in visceral organ weights (gizzard, liver, heart) in T4 could indicate increased digestive workload or metabolic activity associated with greater voluntary intake and processing of more fibrous material. This is consistent with the report of Baptista *et al.* 2023 when they evaluated the potential of spent mushroom substrate for agricultural sustainability.

Table 4. Carcass yield, Cut-parts and Organ Weight Measurement of Broiler Chicks Fed Varying Levels of Mushroom Powder

Parameters (kg)	T1	T2	T3	T4	SEM
Thigh	0.136^{b}	0.124^{c}	0.126^{c}	0.140^{a}	0.002
Wing	0.108^{a}	0.090^{c}	0.103^{b}	0.110^{a}	0.002
Drumstick	0.142^{b}	0.134^{d}	0.136^{c}	0.146^{a}	0.001
Shank	0.078^{a}	0.070^{b}	0.072^{b}	0.080^{a}	0.002
Head	0.090^{b}	0.090^{b}	0.088^{b}	0.094^{a}	0.002
Neck	0.110^{a}	0.094^{b}	0.078^{c}	0.010^{a}	0.003
Gizzard	0.580^{a}	0.540^{b}	0.543^{ab}	0.600^{a}	0.003
Liver	0.029^{a}	0.024^{b}	0.026^{ab}	0.030^{a}	0.002
Heart	0.008^{b}	0.004^{c}	0.004^{c}	0.010^{a}	0.001
Defeathered Weight	3.240^{a}	3.110^{b}	3.122^{b}	3.270^{a}	0.024
Carcass Weight	2.423^{a}	2.358^{b}	2.383^{ab}	2.447^{a}	0.064
Dressing %	67.83^{ab}	67.80^{b}	68.22^{a}	68.51^{a}	0.040

[abcd] Mean values with different superscripts within a row differed significantly at 0.05; SEM= Standard Error of Mean.

CONCLUSION AND RECOMMENDATIONS

From the results obtained, supplementing mushroom powder at 1,1.5, and 2% had no significant improvement on the total weight gain, Average daily weight gain, and feed conversion ratio. However, the treatment significantly influenced the feed intake of the birds at 2% level of inclusion. The research concluded that inclusion of mushroom powder at 2% in broiler diet resulted in optimum feed intake of broiler chicks.

From the results of this study, although treatments recorded no significant increase on the total weight gain, average daily weight gain and feed conversion ratio, higher feed intake was however obtained at 2% inclusion of mushroom powder; therefore, mushroom powder can be included in the concentrate diet of broiler chickens at 2% inclusion level. Further research is required to check the mushroom inclusion at higher levels of inclusion.

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Authors' Contributions

CIE conceptualized the study. CIE & VCA designed the experiment; VCA carried out the experiment, collected data, performed data analysis, and wrote the first draft of the manuscript. VCA performed literature searches and CIE reviewed the first draft of the manuscript. All authors read and approved the final draft of the manuscript.

Ethical Statement

This study adhered to ethical research standards as approved by the Ethical Committee of the Nnamdi Azikiwe University, Nigeria, ensuring responsible data use, informed community participation, non-invasive environmental practices, transparency and adhering to the Animal handling protocols.

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