

EFFECT OF SHIITAKE MUSHROOM (*Lentinula edodes*) SUPPLEMENTATION ON THE GROWTH PERFORMANCE OF BROILER CHICKENS FED DIETS BASED ON FERMENTED SWAPSI MEAL-BASED DIETS

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ABSTRACT

Shiitake mushroom is recognized for its nutritional and bioactive properties, with potential benefits in poultry nutrition. Fermented feed ingredients, such as fermented solid waste product of sugar industry meal, have also gained attention in improving nutrient utilization and growth performance in poultry. This study evaluated the effects of dietary supplementation with Shiitake mushroom on the growth performance of broiler chickens fed diets of fermented SWAPSI meal during an eight-week feeding period divided into starter and finisher phases. A total of 250 broiler chicks were assigned to 5 dietary treatments receiving diets containing varying inclusion levels of Shiitake mushroom combined with fermented SWAPSI meal with 50 birds per treatment and 10 birds per replicate. Initial body weights were similar across treatments. Significant improvements ($P < 0.05$) in final body weight and average weight gain were observed in birds supplemented with 5 % (1391.20 g) and 20 % (1319.80 g) shiitake mushroom compared to the control (788.40 g) and 30 % (715.80 g) groups of finisher phase. In conclusion, 20 % supplementation of Shiitake mushrooms with fermented SWAPSI meal-based diets enhanced growth performance and feed efficiency in broiler chickens.

Keywords: Shiitake mushroom, Supplementation, Growth performance, Broiler chickens, Fermented SWAPSI meal

INTRODUCTION

Shiitake mushroom (*Lentinula edodes*) has gained recognition not only as a culinary delicacy but also as a valuable component in animal nutrition, particularly in poultry diets. Renowned for its rich nutritional profile and bioactive compounds, shiitake mushrooms offer numerous potential benefits when incorporated into animal feed formulations (Chang & Wasser, 2012). Yang *et al.* (2020) observed improved growth performance and immune responses in broilers fed diets containing shiitake mushroom extract.

Similarly, investigations into fermented feed ingredients have highlighted their potential to enhance nutrient utilization and promote gut health in poultry (Hossain *et al.*, 2017). Fermented feedstuffs, such as fermented Solid Waste Product of Sugar Industry (SWAPSI) meal have emerged as a sustainable alternative in animal nutrition, offering numerous advantages, including improved digestibility, reduced anti-nutritional factors, and enhanced nutrient utilization which in turn increase growth performance (Alu *et al.*, 2013). Fermentation processes can further enhance the bioavailability of nutrients and bioactive compounds present in feed ingredients, potentially augmenting their beneficial effects on animal health and performance. The use of fermented Solid Waste Product of Sugar Industry (SWAPSI) meal as a partial

replacement for conventional feed ingredients offers an economical and sustainable alternative in broiler production. Fermentation improves the nutritional quality and digestibility of SWAPSI meal, making it a viable feedstuff for broilers. However, the potential synergistic effects of combining fermented SWAPSI meal with shiitake mushroom supplementation on broiler growth performance remain underexplored. Therefore, this research is necessary.

This study aims to evaluate the effect of dietary shiitake mushroom supplementation on the growth performance of broiler chickens fed fermented SWAPSI meal-based diets. By investigating parameters such as body weight gain, feed intake, and feed conversion ratio, the research seeks to determine whether shiitake mushrooms can enhance the utilization of fermented SWAPSI meal and thus improve overall production efficiency in broiler chickens.

MATERIALS AND METHODS

Location of the Study

The experiment was carried out at the Poultry Unit of the Livestock Farm of the Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi (NSUK), situated Shabu-Lafia Campus, Nasarawa State and the study complied with national and international codes such as the Nigerian

Animal Research Act. The Farm is in the Southern Guinea Savannah Zone, in the middle belt of Nigeria, at coordinates Latitude 8°35'N and Longitude 8°33'E. The area experiences an average minimum temperature of 23 °C and a maximum temperature of 36.9 °C. The average monthly relative humidity and annual average rainfall was measured during the experimental period with an average monthly temperature. Temperature, humidity, and precipitation data was sourced from the weather station of the Faculty of Agriculture at Nasarawa State University, Keffi, Shabu–Lafia Campus.

Sources of Test Ingredients and Processing

Solid waste product of sugar industry (SWAPSI) was sourced from Dangote Sugar Processing Industry in Numan LGA of Adamawa State. The SWAPSI was sun-dried for 2-3 days to reduce the moisture content and to avoid the growth of fungus and rancidity. Thereafter, it was hammer-milled to produced SWAPSI meal. Shiitake mushroom (*Lentinula edodes* [Berk.] Pegler) was obtained from local farms in Lafia, Nasarawa State where most of the trees are cut off. The collected shiitake mushroom was washed, sun-dried and also hammer-milled to produced shiitake mushroom meal (SMM). Other ingredients such as fish meal, lysine, methionine, premix, toxin binder, were purchased from bio-ingredient Ltd Abuja while ground nut cake, palm oil, salt, maize, and rice offal were purchased from Lafia metropolis.

Fermentation of SWAPSI

Bovine rumen fluid was collected from abattoir slaughtered waste generated from slaughtering of cattle in Lafia abattoir. The rumen liquor was filtered through a 100 mm nylon net. The solid materials were discarded while the fluid (liquor) was used to inoculate the SWAPSI by spraying 5 L of rumen liquor per 2 kg of SWAPSI. The sprayed SWAPSI was mixed and transferred into an airtight plastic container to initiate fermentation process that lasted for 72 hours. The fermented samples were sun-dried and analyzed for nutrient composition according to methods of AOAC (2010). The anaerobic spoilage was accounted by ensuring the process environment remains truly anaerobic by preventing oxygen ingress, as oxygen can trigger aerobic spoilage and spoil the ferment and by monitoring for the presence and activity of spoilage microorganisms such as certain clostridia species, which are anaerobic spoilage agents.

Preliminary Investigation of SHIITAKE Mushroom and FSWAPSI

A total of 5 samples (1 per treatment) and replicated 3 times. The proximate composition of SWAPSI was determined using the procedure outlined by AOAC (2010) (Table 1). The amino acid profile was determined using the standard methods of Schroeder and Mills (1990) as outlined by Alu *et al.* (2018). The quantitative phytochemical screening of the test ingredients was carried out at the International

Institutes of Tropical Agriculture (IITA) Ibadan using the standard methods (Harbone, 1973; Trease & Evans, 1989; Sofowora, 1993) adopted by Alu *et al.* (2013) while the values was reported on dry matter basis.

Table 1: Proximate and phytochemical compositions of shiitake mushroom

Parameters	Composition
Moisture content	82.35 g/100 g
Fat content	4.46 g/100
Ash content	0.84 g/100 g
Dietary fibre	11.20 g/100 g
Polyphenols	28.52 mg/100 g
Gama amino-butyric acid (GABA)	4.70 mg/100 g
Ergothionine	15.63 mg/100 g

Experimental Diets for Broiler Chicks and Finisher

The experimental diets contained 20 % fermented SWAPSI meal replacing maize with varying level of shiitake mushroom meal (SMM) at 0 % Control (T₁), 0 % (T₂), 5 % (T₃), 10 % (T₄), 20 % and (T₅), 30 % supplementation; the diets were formulated to meet the nutrient requirements of broiler chicks and chickens respectively. Other ingredients included at the recommended levels for both starter and finisher phases. The diet composition is as shown in Tables 2 and 3.

Table 2: Experiment diets for broiler chicks

Ingredients	T1 (0%)	T2 (5%)	T3 (10%)	T4 (20%)	T5 (30%)
*FSWAPSI	8.00	8.00	8.00	8.00	8.00
Maize	35.00	35.00	35.00	35.00	35.00
Maize bran	15.00	15.00	15.00	15.00	15.00
Fish meal	1.00	1.00	1.00	1.00	1.00
Groundnut cake	36.00	36.00	36.00	36.00	36.00
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone meal	1.00	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
**Premix	0.25	0.25	0.25	0.25	0.25
Common Salt	0.25	0.25	0.25	0.25	0.25
Palm oil	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100
Toxin binder	+	+	+	+	+
Acidifier	+	+	+	+	+
*SMM (%)	0	5	10	20	30
Calculated Energy					
Energy (kcal/kg, ME)	2809.51	2809.51	2809.51	2809.51	2809.51
Crude protein (%)	23.22	23.22	23.22	23.22	23.22
Crude fibre (%)	5.61	5.61	5.61	5.61	5.61
Ether extract (%)	6.40	6.40	6.40	6.40	6.40
Ash (%)	2.98	2.98	2.98	2.98	2.98
Calcium (%)	0.57	0.57	0.57	0.57	0.57
Phosphorus (%)	0.80	0.80	0.80	0.80	0.80
Lysine (%)	1.14	1.14	1.14	1.14	1.14
Methionine (%)	0.53	0.53	0.53	0.53	0.53

FSWAPSI= Fermented Solid waste product of sugar industry, SMM= Shiitake Mushroom

Table 3: Experiment diets for broiler finisher

Ingredients	T1 (0%)	T2 (5%)	T3 (10%)	T4 (20%)	T5 (30%)
*FSWAPSI	8.00	8.00	8.00	8.00	8.00
Maize	50.00	50.00	50.00	50.00	50.00
Maize bran	10.00	10.00	10.00	10.00	10.00
Fish meal	1.00	1.00	1.00	1.00	1.00
Groundnut cake	25.00	25.00	25.00	25.00	25.00
Blood meal	2.05	2.05	2.05	2.05	2.05
Bone meal	1.00	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
**Premix	0.20	0.20	0.20	0.20	0.20
Common Salt	0.25	0.25	0.25	0.25	0.25
Palm oil	2.00	2.00	2.00	2.00	2.00
Total	100	100	100	100	100
Toxin binder	+	+	+	+	+
Acidifier	+	+	+	+	+
*SMM	0.00	0.05	0.10	0.20	0.30
Calculated energy					
Energy(kcal/kg, ME)	3004.27	3004.27	3004.27	3004.27	3004.27
Crude protein (%)	19.05	19.05	19.05	19.05	19.05
Crude fibre (%)	5.07	5.07	5.07	5.07	5.07
Ether extract (%)	6.90	6.90	6.90	6.90	6.90
Ash (%)	2.53	2.53	2.53	2.53	2.53
Calcium (%)	0.61	0.61	0.61	0.61	0.61
Phosphorus (%)	0.78	0.78	0.78	0.78	0.78
Lysine (%)	0.99	0.99	0.99	0.99	0.99
Methionine (%)	0.52	0.52	0.52	0.52	0.52

FSWAPSI = Fermented Solid waste product of sugar industry,
SMM = Shiitake Mushroom

Experimental Design

A total of 250-day old broiler chicks were used for the experiment which lasted for 56 days; the birds were randomly allotted to five dietary treatments at the rate of 50 birds per treatment; each treatment was replicated 5 times having 5 birds each in a Completely Randomized Design (CRD). The starter and finisher phases lasted for 0-4 weeks and 5-8 weeks, respectively.

Management of Experimental Birds

As outlined by Alu (2013), the birds were weighed at the beginning of research and given a weighed amount of dietary feed while water was provided *ad libitum*. Prior to arrival of the birds, suitable disinfectant Neodine DSL was used to eliminate any microorganisms that could predispose the birds to diseases. The feed trays and drinkers were properly washed and disinfected. Wood shavings were spread on the cemented floor up to a depth of 5 cm to serve as insulator and moisture absorbent from droppings. Charcoal heated pots were used as a heat source to maintain brooding temperature at 32 °C during the first week, gradually reduced thereafter. Vitamin and glucose were incorporated into their water to reduce stress. The chicks were vaccinated against Gumboro at 1st week and new castle at 2nd week. The vaccine was repeated at 3rd and 4th week, respectively. Proper sanitation was maintained throughout the period of the experiment and the litter materials was changed periodically while feeders and drinkers were washed regularly as described by Yunana *et al.* (2020).

Data Collection

Data on growth performance was taken and recorded for both starter and finisher phases as described by Kwari *et al.* (2011) and Sani *et al.* (2021) data collected included:

Weekly body weight: this was obtained by weighing the birds every 7 days.

Bodyweight gain: this was measured by the difference between the final weight and the initial weight of the animal.

Feed intake: the birds were allocated a weighed number of feeds daily, and their corresponding left over weighed and recorded (Nakkazi *et al.*, 2015; Yi *et al.*, 2018). Daily feed intake was measured as the difference between the amount of feed fed and the leftover.

Feed conversion ratio: this was calculated as the rate of feed intake to live weight gain:

$$FCR = \frac{\text{feed intake (g)}}{\text{body weight gain (g)}}$$

Statistical Analysis

All data collected were analysed using a one-way analysis of variance (ANOVA) utilizing the General Linear Model in IBM SPSS version 20. Means with significant difference were compared using Duncan's Multiple Range Test (DMRT) at a 95 % confidence interval.

The following statistical model was employed:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Y_{ij} = individual observation; μ = population mean; T_i = Treatment effect; e_{ij} = Error effect

RESULTS AND DISCUSSION

Effects of Shiitake Mushroom on Growth Performance of Broiler Chicks Fed Fermented SWAPSI Diets

Table 4 shows the effects of dietary shiitake mushroom supplementation on the growth performance of broiler starter fed fermented SWAPSI meal-based diets. The result indicated that groups receiving shiitake mushroom supplementation demonstrated significantly ($P < 0.05$) higher FBW at 20 % (479.20 g/bird) and AWG at 5% (132.20 g/bird). The FCR at 30 % (1.05 g/bird) was also significantly ($P < 0.05$) improved, suggesting enhanced feed efficiency. There was no significant difference observed in AFI among the groups, indicating that the improved weight gain and efficiency were due to better nutrient utilization.

The observed ($P < 0.05$) enhancements in final body weight at 5 % (1391.20 g/bird), average weight gain at 5 % (841.80 g/bird), and feed conversion ratio at 20 % (1.09 g/bird) in broiler chickens supplemented with Shiitake mushroom were consistent with prior studies demonstrating that the bioactive compounds derived from mushrooms, particularly polysaccharides, could significantly improve nutrient absorption, intestinal health, and immune function in poultry (Wang *et al.*, 2020). These bioactive constituents have been reported to modulate the gut microbiota by promoting beneficial

bacterial populations, thereby facilitating enhanced digestive efficiency and nutrient uptake, which collectively contribute to improved growth performance. Comparable beneficial effects have been documented (Sugiharto *et al.*, 2018) with the inclusion of fermented plant-based protein sources, such as fermented soybean meal in broiler diets. Fermentation processes are known to reduce anti-nutritional factors and increase the bioavailability of essential amino acids and peptides, thereby supporting growth performance and feed efficiency without eliciting an increase in feed intake (Sugiharto *et al.*, 2018; Kim *et al.*, 2022). The combined use of fermented SWAPSI meal and shiitake mushroom supplementation likely exerts a synergistic effect, enhancing gut health and nutrient utilization more effectively than either intervention alone. The findings of this study have significant implications

for broiler chicken production. The observed improvement in FCR indicates a reduction in feed intake per unit of weight gain, thereby decreasing overall feed costs and enhancing economic efficiency for producers. Furthermore, the incorporation of natural feed additives such as shiitake mushroom (*Lentinula edodes*) may mitigate the need for antibiotic growth promoters, contributing to improved flock health and aligning with increasing consumer preferences for antibiotic-free poultry products. Additionally, the enhanced weight gain and final body weight observed with shiitake supplementation have the potential to increase marketable yields, thereby improving profitability and sustainability in commercial broiler production systems.

Table 4: Effects of Shiitake mushroom on growth performance of broiler starter fed fermented SWAPSI diets

Parameters	Shiitake inclusion levels					SEM	P-value
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (20%)	T5 (30%)		
IBW (g/bird)	53.00	48.40	49.20	52.00	50.00	0.71	0.213 ^{ns}
FBW (g/bird)	345.20 ^{cd}	398.20 ^b	385.20 ^{ab}	479.20 ^a	321.60 ^d	17.47	0.000*
AWG (g/bird)	126.20 ^{ab}	132.20 ^a	132.60 ^a	130.60 ^a	118.40 ^b	2.821	0.007*
AFI (g/bird)	112.20 ^c	155.60 ^a	155.40 ^a	143.60 ^{ab}	124.60 ^{bc}	4.78	0.003*
FCR	0.88	1.17	1.17	1.09	1.05	0.00	0.100 ^{ns}

^{abc} Means with different superscripts within the same row differs significantly (P<0.05), IBW= Initial body weight, FBW= Final body weight, AWG= Average weight gain, AFI= Average feed intake, FCR= Feed conversion ration

Table 5: Effects of Shiitake on growth performance of broilers finisher fed fermented SWAPSI diets

Parameters	Shiitake mushroom inclusion levels					SEM	P-value
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (20%)	T5 (30%)		
IBW (g/bird)	345.20	398.20	385.20	379.20	321.60	17.47	0.300 ^{ns}
FBW (g/bird)	1225.91 ^{ab}	1391.20 ^a	1267.20 ^{ab}	1319.80 ^{ab}	1101.16 ^b	41.42	0.0243*
AWG (g/bird)	788.40 ^{ab}	841.80 ^a	802.60 ^{ab}	843.80 ^a	715.80 ^b	17.10	0.000*
AFI (g/bird)	298.80	281.80	282.00	275.00	257.80	12.27	0.656 ^{ns}
FCR	0.37	0.33	0.35	0.32	0.36	0.00	0.100 ^{ns}

^{ab} Means with different superscripts within the same row differs significantly (P<0.05), IBW= Initial body weight, FBW= Final body weight, AWG= Average weight gain, AFI= Average feed intake, FCR= Feed conversion ration

Effects of Shiitake Mushroom on Growth Performance of Broiler Finisher Chickens Fed Fermented SWAPSI Diets

Table 5 presents the effects of Shiitake on growth performance of broilers finisher fed fermented SWAPSI diets. The performance indicators assessed include initial body weight, final body weight, average weight gain, average feed intake, and feed conversion ratio. There was no significant difference (P>0.05) in initial body weight among the treatment groups, indicating that all birds commenced the experiment with comparable baseline weights, thereby ensuring uniformity and validating that subsequent performance variations are attributable to dietary treatments. Final body weight at 5 % (1391.20 g/bird) was significantly (P<0.05) affected by dietary inclusion of Shiitake mushroom. The group receiving 5 % SMM supplementation attained the highest FBW (1391.20 g), which was significantly (P>0.05) greater than that of the 30 % SMM group (1101.16 g) and marginally superior to the control group (1225.91 g). This suggests that low-level inclusion of SMM enhances growth

performance, potentially due to the presence of bioactive compounds such as β-glucans and polysaccharides that promote gut health and nutrient absorption (Wang *et al.*, 2020; Sun *et al.*, 2023). Similarly, average weight gain was significantly (P>0.05) influenced by SMM supplementation (P<0.05). Broilers fed diets containing 5 and 20 % SMM exhibited superior (P>0.05) weight gains of 841.80 g and 843.80 g, respectively, compared to those receiving 30 % SMM (715.80 g), indicating a possible threshold beyond which higher inclusion levels may adversely affect nutrient utilization or feed palatability. This observation is consistent with the findings by Sugiharto *et al.* (2018) who reported diminished performance at elevated inclusion rates of fermented feed ingredients, likely due to increased fiber content and residual anti-nutritional factors. Average feed intake did not differ significantly (P>0.05) among treatments, although a numerical decline was observed with increasing SMM inclusion, ranging from 298.80 g in the control group to 257.80 g in the 30 % SMM group. This trend may reflect

reduced palatability or increased dietary fiber associated with higher mushroom levels. Feed conversion ratio was not statistically different ($P>0.05$) across treatments. However, the most efficient FCR (0.32) was recorded in the 20 % SMM group, whereas the control group exhibited the poorest FCR (0.37). The improved ($P>0.05$) FCR at moderate SMM inclusion levels may be attributed to enhanced gut microbial balance and elevated digestive enzyme activity mediated by mushroom-derived polysaccharides and fermentation metabolites (Feng *et al.*, 2020). Collectively, these results suggest that moderate supplementation of Shiitake mushroom in fermented SWAPSI meal-based diets optimizes growth performance and feed efficiency in broiler chickens, while excessive inclusion may impair nutrient utilization, possibly due to increased fiber or anti-nutritional factor content.

CONCLUSION

It can be concluded that 5 – 20 % SMM inclusion in fermented SWAPSI diets provided the best outcome in terms of growth performance and feed efficiency. However, 30 % inclusion negatively impacted performance metrics, suggesting that over-supplementation may have contributed to decreased feed intake or nutrient imbalances. Broilers receiving Shiitake supplementation consistently showed higher final body weight and average weight gain, along with improved feed conversion ratio when compared to the control groups. More importantly, these improvements were achieved without a significant increase in average feed intake, indicating enhanced feed efficiency and nutrient utilization.

It is recommended that Shiitake mushroom (*Lentinula edodes*) supplementation be incorporated at inclusion levels up to 20 % in both starter and finisher broiler diets, particularly when formulated with alternative protein sources such as fermented SWAPSI meal. This strategy has been demonstrated to optimize growth performance and enhance feed efficiency. Furthermore, fermented SWAPSI meal represents a viable partial substitute for conventional feedstuffs in broiler nutrition, offering a sustainable and economically advantageous approach to poultry production.

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