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Growth Performance and Body Condition Score of Pregnant and Lactating West African Dwarf Goats Fed Microbial-Treated Rice Husk-Based Diets

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Abstract

Rice husk is an abundant agricultural by-product with limited use in ruminant feeding due to its low protein, and high fibre contents. This study evaluated the effects of microbial-treated rice husk-based diets on growth performance and body condition score of pregnant and lactating West African Dwarf goats. Rice husk was subjected to biological treatment using *Alcaligenes faecalis*, *Aspergillus flavus*, and a combination of both microorganisms before inclusion in experimental diets as a substitute for twenty-five percent maize. Forty healthy nulliparous West African Dwarf does were randomly assigned to four dietary treatments in a completely randomized design and managed throughout gestation and seven weeks after parturition. Nutritional analysis revealed that microbial treatment significantly improved the quality of rice husk, increasing crude protein from 4.43% in the raw sample to 10.68–11.14% in treated samples, while maintaining comparable ash and fibre contents. Growth performance of pregnant goats was significantly influenced by dietary treatment, with average daily weight gain ranging from 68.03 to 68.98 g/day in treated groups compared with 76.67 g/day in the maize-based control. Similarly, lactating goats fed treated rice husk diets recorded average daily weight gains of 18.78–22.02 g/day compared with 26.33 g/day in the control group. Despite these reductions, treated diets sustained satisfactory growth and maintained body condition throughout the experimental period. Body condition score was not significantly affected by treatment and ranged from 4.45 to 4.90 across diets. The results demonstrate that microbial bioconversion substantially enhanced the feeding value of rice husk and supports its valorization as a sustainable alternative feed resource capable of partially replacing conventional feed ingredients in diets of breeding West African Dwarf goats.

Keywords: *Rice husk, WAD goat, Pregnant, Lactating, Fungi, Bacteria*

Introduction

West African Dwarf (WAD) goats are a small, trypanotolerant breed important to many rural West African farming regions, providing meat, milk, and income (Afolayan *et al.,* 2025), however, production is limited by scare, expensive and low-quality forage, especially during the long dry season (Ogunbosoye *et al.* 2022). To address these gaps, agro-industrial by-products have been explored as alternative ruminant feeds. One promising, abundant but underutilized feed resource is rice husk (RH). According to Nnadiukwu *et al.,* 2023, raw RH is very low in crude protein (~ 1.9%) and high in ash (~ 23.4%) and crude fibre (~ 25.7%). These properties, high crude fiber and ash content mean rice husk provides little nutritional value in its untreated form (Kolade *et al.,* 2024). To improve the nutrient content of rice husk, white-rot fungal fermentation by *Pleurotus ostreatus* has been reported to improve rice husk crude protein (CP) by a staggering 44.17%, and also notable reductions in fiber (NDF, ADF) and lignin (Dairo *et al.,* 2017). Afolayan *et al.* (2025) found that solid-state fermentation (SSF) (bacteria + fungus) increased RH crude protein from ~9.9% (untreated) to 11.1% and lowered crude fibre from 66.79% to 62.04%. *Trichoderma viride* treatment similarly reduced RH NDF and ADF markedly after 4–6 weeks (Aderolu *et al.,* 2007).

Pregnancy and lactation impose very high nutritional demands on does (Chen *et al.,* 2024) with any energy and or protein deficiency resulting to slow growth, longer kidding intervals and higher kidding mortality (Ogunbosoye *et al.,* 2022). Microbial-treated RH diets can sustain satisfactory goat growth at lower cost, provided RH inclusion is kept moderate (often ≤50%) and the overall nutrient balance is maintained (Afolayan *et al.,* 2024, Afolayan *et al.,* 2025). However, limited studies have investigated microbial-treated RH in breeding does. The current experiment evaluated diets in which 25% maize was substituted by rice husk fermented with bacteria (*Alcaligenes faecalis*), fungi (*Aspergillus flavus*) or a 1:1 of both, and measured pregnant and lactating WAD doe growth and body condition. The hypotheses were that (1) microbial treatment will raise RH's CP, and (2) does fed treated-RH diets will perform comparably to the control diet, maintaining weight gain and Body Condition Score.

Materials and Methods

Experimental site

This experiment was carried out at the small ruminant unit, Afolayan Farms, Oro, Irepodun Local Government Area, Kwara State, Nigeria which lies between the latitude of 8.2258° N and longitude 4.8923° E.

Experimental Materials and Inoculation

Rice husk samples were sourced, cleaned, and sterilized in an autoclave at 121°C for 15 minutes. The sterilized rice husk was inoculated with each microbe separately at 1ml of spores to 9mL saline water and 1kg of substrate to 1 litre of water. Incubation lasted 10 days, after which the fermented substrates were subsequently dried to safe storage moisture level, packaged, labeled, and stored prior to diet formulation.

Experimental Animals and Diets

Forty healthy, nulliparous West African Dwarf does were randomly assigned to four dietary treatments in a completely randomized design (CRD), with 10 does per treatment serving as replicates. Animals were approximately 20-24 months old, estimated from dentition and farmers records. After a 30-day adaptation period, does were bred by proven bucks and managed throughout gestation and 7 weeks postpartum. Growth parameters were recorded over an average of approximately 147 days. The entire experiment, including adaptation and breeding management was conducted over a period of 7.5 months. Four diets (Table 1) were formulated using common ingredients, variation existing only in the 25% maize fraction. In the control (T1) this fraction was maize, in T2-T4 it was substituted by rice husk treated with; bacteria (*Alcaligenes faecalis*), fungi (*Aspergillus flavus*) or a 1:1 bacterium + fungi cocktail, respectively. All diets were formulated to contain ~15% crude protein and meet the nutrient requirements of pregnant does. Feed ingredients were analyzed by standard methods (Horwitz & Latimer, (2005) for proximate composition; Van Soest, (1991) for fiber fractions)

Table 1. Composition of Treatment Diets

	Diets (kg)			
Ingredients	T1 (Control)	T2 (B-RH)	T3 (F-RH)	T4 (B+F-RH)
Treated rice husk	-	25	25	25
Maize	25	-	-	-
Soya beans meal	15	15	15	15
Palm kernel cake	10	10	10	10
Groundnut cake	10	10	10	10
Cassava peel	20	20	20	20
Wheat bran	15	15	15	15
Bone meal	2.5	2.5	2.5	2.5
Salt	1	1	1	1
Premix	1.5	1.5	1.5	1.5
Total	100	100	100	100

Keys: Control= Maize diet, B-RH=Bacterial treated rice husk, F-RH =Fungi treated rice husk, B+F-RH = Bacterial + Fungi treated rice husk

Animal Feeding and Management

The does were fed weighed treatment diets twice daily, and water was provided ad libitum. The initial body weights of the animals were recorded at the commencement of the feeding trial, and weekly recordings were taking subsequently by estimation using body measurements (Afolayan *et al.*, 2006). Feed intake (FI) was recorded daily, total weight gain, and average daily weight gain were calculated using the weekly records. Feed conversion ratio (FCR) was also calculated.

BW (kg)= HG^2(cm)×BL (cm) / 10840

Body condition score (BCS) was assessed at regular intervals using a 1–5 scoring scale, where 1 represented skinny and 5 represented obese animals. Scores were assigned by visual appraisal and palpation of the lumbar region, sternum and ribs. Mean BCS values obtained during the trial period were subjected to statistical analysis.

Statistical analysis

Data recorded were subjected to one-way Analysis of Variance (ANOVA) using the DSAASTAT version 1.101 (Onofri, 2011). Where significant treatment effects were detected, means were separated using the Least Significant Difference (LSD) test at $P < 0.05$.

Results

Nutritional Analysis of Treated Rice husk Samples

The nutritional analysis, as presented in Table 2 revealed significant (P< 0.05) improvement in the nutritional values of treated rice husk. Crude protein (CP) jumped from 4.43% in raw rice husk all the way to 11.14% in the cocktail treatment, while dry matter also saw an increase compared to the maize control (93.19 - 95.25%). Crude fibre, and ash remained comparable across treatments, showing no significance.

The results revealed all proximate and fibre fraction parameters were significantly (P< 0.05) different, except for CP which remained comparable across treatments (15.86 to 16.55%) confirming the diets were isonitrogenous. Microbial-treated rice husk increased the crude fibre from 24.02% in the maize control diet, to ~ 25.2% in the bacterial-treated diet, with a similar trend observed in the carbohydrate content. Similarly, NDF, ADF and lignin content followed the same pattern with the control diet presenting the lowest value compared to the treated diets. On the other hand, total ash decreased from 13.92% in control to the extreme end again in the bacterial-treated diet.

Table 2: Nutritional Analysis of Treated Rice husk Samples

	Treatments					
Parameters (%)	(RRH)	(BTRH)	(FTRH)	(B+FTRH)	SEM	p-Value
Dry matter	93.19^{a}	95.25^{c}	94.39^{b}	94.40^{b}	0.163	0.0001**
ASH	18.46	18.55	18.91	14.48	3.001	0.7027
Crude fibre	66.79	66.85	65.62	62.04	1.198	0.0670
Crude fat	4.59^{a}	4.09^{b}	4.19^{b}	4.14^{b}	0.106	0.0395*
Crude protein	4.43^{b}	10.71^{a}	10.68^{a}	11.14^{a}	0.209	3.7E-08**
Carbohydrate	57.29^{ab}	58.08^{a}	56.37^{bc}	55.25^{c}	0.395	0.0050**

Keys: a,b,c = means within the same row with different superscripts are significantly (P<0.05) different. RRH: raw rice husk, BTRH: Bacteria treated rice husk, FTRH: fungi treated rice husk, B+FRH: Bacteria + Fungi treated rice husk (cocktail).

Table 3: Proximate and Fibre Fraction Composition of the Experimental Diets.

	Treatments					
Parameters (%)	T1	T2	T3	T4	SEM	p-value
Dry matter	89.62^{d}	88.83^{a}	89.03^{b}	89.31^{c}	1.07E-02	1.06E-10**
Total Ash	13.92^{a}	9.89^{d}	12.18^{b}	11.30^{c}	4.02E-02	1.28E-11**
Crude Fibre	24.02^{d}	25.21^{a}	24.26^{c}	24.96^{b}	2.77E-02	<0.01**
Crude Fat	5.17^{a}	4.27^{d}	4.89^{b}	4.45^{c}	4.66E-02	2.97E-06**
Crude Protein	15.97	15.86	15.86	16.55	0.34	0.0667
CHO	50.56^{c}	53.63^{a}	52.69^{b}	52.83^{b}	9.46E-02	8.58E-08**
Neutral detergent soluble	23.01^{a}	21.40^{c}	22.25^{b}	21.4^{c}	0.175	0.000488**
Neutral detergent fibre	74.99^{c}	78.43^{a}	77.76^{b}	78.6^{a}	0.154	0.00029**
Acid detergent fibre	52.83^{c}	54.13^{b}	53.91^{b}	54.79^{a}	0.115	1.56E-05**
Acid detergent Lignin	10.24^{d}	11.46^{a}	10.97^{c}	11.38^{b}	2.369E-02	1.28E-09**
Silica	8.24^{d}	8.62^{b}	8.71^{a}	8.49^{c}	1.093E-02	4.64E-07**
Cellulose	22.16^{c}	24.3^{a}	23.85^{b}	23.81^{b}	7.23E-02	0.003319**
Hemicellulose	42.67^{b}	42.67^{b}	42.95^{ab}	43.31^{a}	0.139	0.025237*

Keys: a,b,c = means within the same row with different superscripts are significantly (P<0.05) different TI = Diet with maize (control), T2 = diet with *Alcaligenes faecalis* (Bacteria), T3 = Diet with *Aspergillus flavus*, T4 = *Diet with Alcaligenes faecalis + Aspergillus flavus*

Growth Performance Response in Pregnant and Lactating WAD Goats to Diets

Dietary treatment showed a significant (P < 0.05) influence on growth parameters of pregnant WAD goats. The control had the highest (76.67 g/day) average daily weight gain (ADWG) and declined to 68.03–68.98 g/day in goats fed microbial-treated rice husk diets. In a similar trend, total weight gain dropped from 11.27 kg in the control diet to 10.00–10.14 kg in the treated groups (P = 0.024) with the bacterial-treated rice husk recording the lowest value. Feed intake was also affected, with total feed intake of 70.46 to 72.89 kg in treated diets compared with 74.22 kg in the control, while average daily feed intake also saw a declined from 503.97 to 480.49–495.89 g/day (P < 0.05). Dietary treatment had no significant (P > 0.05) effect on the initial and final body weights, as well as feed conversion ratio 6.59–7.19.

The significant (P < 0.05) effects of the dietary treatment on growth performance extended till lactation. With average daily weight gain (ADWG) ranging from the lowest in fungi treated husk, 18.78 to 22.02 g/day in the mixture as compared with 26.33 g/day in the control group. Similarly, total weight gain declined from 1.29 kg in the control group to 0.94–1.11 kg in the treated groups (P < 0.05). Extending the significance trend, total feed intake and average daily feed intake were also affected, decreasing from 39.99 kg and 816.09 g/day in the control

group to 34.74–39.15 kg and 708.89–799.06 g/day, respectively, in the treated groups. Feed conversion ratio was also significantly affected (P = 0.022), ranging from 35.27 to 37.73 in goats fed treated rice husk diets compared with 31.00 in the control group. However, similar to the pregnant does results, initial and final body weights were not significantly influenced by dietary treatment (P > 0.05) in the lactating does.

The body condition score results presented no significant (P = 0.14) dietary effect on body condition score (BCS) of pregnant and lactating WAD goats. Mean BCS values ranged from 4.45 to 4.90 across treatments, with goats fed the control diet recording the highest score (4.90) and those fed the bacteria + fungi-treated rice husk diet at the lower extreme (4.45). Despite the numerical differences observed, body condition scores remained high and comparable across all treatment groups.

Table 4: The Growth Performance of Pregnant WAD Goats Fed Experimental Diets.

	Treatments					
Parameters	T1	T2	T3	T4	SEM	p-value
Initial weight (kg)	15.43	15.42	15.44	15.47	1.26	0.99
Final weight (kg)	26.70	25.52	25.44	25.61	1.38	0.91
ADWG (g)	76.67^{a}	68.71^{b}	68.03^{b}	68.98^{b}	2.16	0.024*
Total Weight Gain (kg)	11.27^{a}	10.10^{b}	10.00^{b}	10.14^{b}	0.32	0.024*
Total Feed Intake (kg)	74.22^{a}	72.09^{ab}	70.46^{b}	72.89^{a}	0.71	0.0058**
ADFI (g)	503.97^{a}	490.43^{ab}	480.49^{b}	495.89^{a}	4.73	0.01*
FCR	6.59	7.14	7.05	7.19	0.21	0.23

Keys: a,b,c = means within the same row with different superscripts are significantly (P<0.05) different, TWG = Total weight gain, ADWG = Average daily weight gain, TDFI = Total daily feed intake, ADFI = Average daily feed intake, FCR = Feed conversion ratio. TI = Diet with maize (control), T2 = diet with *Alcaligenes faecalis* (Bacteria), T3 = Diet with *Aspergillus flavus*, T4 = *Diet with Alcaligenes faecalis* + *Aspergillus flavus*

Table 5: The Growth Performance of Lactating WAD Goats Fed Experimental Diets.

	Treatments					
Parameters	T1	T2	T3	T4	SEM	p-value
Initial weight (kg)	20.51	18.07	18.05	19.16	1.05	0.32
Final weight (kg)	21.81	19.07	18.97	20.27	1.07	0.22
ADWG (g)	26.33^{a}	20.21^{b}	18.78^{b}	22.02^{b}	1.08	0.0001**
Total Weight Gain (kg)	1.29^{a}	1.00^{bc}	0.94^{c}	1.11^{b}	5.1E-02	0.0001**
Total Feed Intake (kg)	39.99^{a}	37.73b	34.74^{c}	39.15^{a}	0.49	2.4E-08**
ADFI (g)	816.09^{a}	770.02^{b}	708.89^{c}	799.06^{a}	9.96	2.3E-08**
FCR	31^{b}	37.73^{a}	36.96^{a}	35.27^{ab}	1.86	0.022*

Keys: a,b,c = means within the same row with different superscripts are significantly (P<0.05) different, TWG = Total weight gain, ADWG = Average daily weight gain, TDFI = Total daily feed intake, ADFI = Average daily feed intake, FCR = Feed conversion ratio. TI = Diet with maize (control), T2 = diet with *Alcaligenes faecalis* (Bacteria), T3 = Diet with *Aspergillus flavus*, T4 = *Diet with Alcaligenes faecalis* + *Aspergillus flavus*

Table 6: Body Condition Scoring in Pregnant and Lactating WAD Goats Fed Experimental Diets.

Treatments	Body Condition Score
T1	4.90
T2	4.80
T3	4.70
T4	4.45
SEM	0.16
p-Value	0.14

T1 = control maize diet, T2 = bacteria-treated rice husk, T3 fungi-treated rice husk =, T4 = bacteria + fungi-treated rice husk)

Discussion

The substantial jump in crude protein content after microbial fermentation confirms the efficiency in enhancing the nutritive quality of rice husk. Similar findings have been reported following microbial treatment of rice husk and other lignocellulosic residues (Aderolu *et al.*, 2007; Afolayan *et al.*, 2025 Dairo *et al.*, 2017; Nnadiukwu *et al.*, 2023). Improvements such as this have been attributed to microbial biomass synthesis and partial breakdown of carbohydrates, leading to improved nutritional value of the substrate (Van Soest, 1994; Chen *et al.*, 2024).

Although the performance of the maize-based control diet outweighs the other treatments, goats placed on microbial-treated rice husk diets sustained satisfactory growth during pregnancy and lactation, thereby suggesting that the treated rice husk was able to support heightened nutrient demands attributed with these physiological

periods (Chen *et al.*, 2024). This finding agrees with reports that biologically treated agro-industrial by-products can partially replace conventional feed ingredients in small-ruminant diets without severely compromising animal performance and with economic benefits (Afolayan *et al.*, 2024; Ogunbosoye *et al.*, 2022).

The lack of dietary effects on body condition score suggests the experimental diets adequately maintained body reserves throughout pregnancy and lactation. Since body condition is an important indicator of nutritional status and reproductive efficiency in breeding does, this result demonstrates the potential of microbial-treated rice husk as a sustainable alternative feed resource for WAD goat production systems, especially in regions of forage scarcity and expensive feed materials (Ogunbosoye *et al.*, 2022).

Conclusion

Treatment rice husk with microbes substantially enhanced the nutritional quality, particularly through increased crude protein content, demonstrating its potential for value addition and utilization in ruminant nutrition. Despite the maize-based control diet produced higher growth rates, diets containing microbial-treated rice husk maintained satisfactory growth performance, especially in body condition score of pregnant and lactating WAD goats. The lack of detrimental consequences on body condition score further indicates that treated rice husk can support the high nutritional demands of breeding does. Therefore, microbial bioconversion presents a potential for the valorization of rice husk, changing an otherwise waste, and abundant agricultural by-product into a useful feed resource capable of partially replacing conventional feed ingredients in small-ruminant production systems.

Conflict of Interest

The authors declare no conflict of interest.

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