

## GROWTH AND NUTRIENT UTILIZATION IN STALL-FED WEST AFRICAN DWARF SHEEP UNDER VARYING FEED TIMES

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### ABSTRACT

The productive efficiency of feed in ruminants depends not only on its quality and quantity but also on the timing of delivery. This study evaluated the effect of different feed delivery times on the growth performance, nutrient digestibility, and nitrogen metabolism of West African Dwarf (WAD) sheep. Fifteen WAD sheep (initial weight: 8.26–9.29 kg) were randomly assigned to three feeding time treatments (T1, T2, T3), with five animals per group. Over a 63-day trial, weekly feed intake, body weight gain, and feed efficiency were monitored. Three animals per treatment were later selected for digestibility and nitrogen balance studies. Results showed that overall weight gain and daily weight gain were significantly higher ( $P < 0.05$ ) in T1 (4.92 kg, 78.06 g/day) and T3 (4.95 kg, 78.51 g/day) compared to T2 (2.34 kg, 37.21 g/day). Although total supplemental, grass, and feed intake were higher ( $P < 0.05$ ) in T2 and T3 than in T1, feed conversion ratio was significantly better in T1 and T3 (5.60) compared to T2 (11.73). Dry matter digestibility was significantly improved ( $P < 0.05$ ) in T1 and T3, while other nutrient digestibility parameters and nitrogen balance did not differ significantly ( $P > 0.05$ ) among treatments. It was concluded that feeding *Panicum maximum* and supplements in the evening enhanced feed intake, weight gain, and nutrient digestibility in WAD sheep.

## 1. INTRODUCTION

Livestock production is an important driver of socio-economic progress, improving both income and quality of life. In Africa, livestock contributes approximately 36.5% of total protein intake (NISER/CBN, 2012). Sheep are valuable livestock due to their ability to convert forages and crops into meat, fibers, skin, and milk. The performance and productivity of ruminants can be influenced by the timing of feed delivery, even when the feed's quantity and quality are unchanged. The delivery of fresh feed stimulates eating and affects diurnal eating patterns (Phillips and Rind, 2001; DeVries et al., 2003).

Additionally, the timing of feed delivery affects rumen ecology, influencing feed intake, digestibility, average daily gain, and overall animal performance (Soto-Navarro et al., 2000; Schwartzkopf-Genswein et al., 2004). Ruminants may also adjust the timing of their most intense eating periods to regulate postprandial rhythms and daily intake (Nikkhah et al., 2006; 2007; 2008; 2011). Although several studies have examined ruminant performance based on feed quantity (Soto-Navarro et al., 2000; Schwartzkopf-Genswein et al., 2003; Schwartzkopf-Genswein et al., 2004; Robles et al., 2007), limited research has focused on the impact of feed delivery timing on the performance of sheep fed forage-based supplemental diets. Feed is a major factor influencing animal productivity, and to increase the productivity of ruminants grazing on natural pastures, concentrating supplementation is often required (Devendra and McLeroy, 1982; Adeneye and

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Sunmonu, 1994; Adewumi et al., 2004). This presents a challenge for ruminant nutritionists to efficiently utilize feed resources and manage feeding practices to ensure optimal performance. In light of research on how feeding times affect nutrient utilization in the rumen, various feeding strategies have been developed to minimize issues like ruminal acidosis in cattle fed high-concentrate diets (Bevans et al., 2005; Schwartzkopf-Genswein et al., 2004; Nikkah et al., 2011). The aim of this study is to explore the relationship between feeding management and intake, focusing on how this relationship influences growth and feed utilization efficiency in livestock animals, with the goal of providing insights into optimizing livestock feeding strategies (Adjibode et al., 2017; Oluwadele and Adewumi, 2021).

## 2. MATERIALS AND METHODS

### Experimental site

The experiment was carried out at the Sheep Unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. It is situated in the derived savanna vegetation belt (Latitude 7°27'N and 3°45'E) at an altitude between 200m and 300m above sea level; mean temperature of 25°C - 29°C with an average annual rainfall of about 1250 mm. Babayemi et al., (2003) reported that the soils are much drained and belong to the alfisol.

### Panicum maximum collection

The grass materials were cut to a chopping length of approximately 5cm using knives, it was also wilted and were fed on dry matter basis to the sheep.

### Cassava peel collection

Dry cassava peels were collected at a market in Eleyele, Ibadan and were fed to the sheep.

### Experimental animal and management

Fifteen healthy West African dwarf's rams aged between 6 to 8 months with weight range of 8.26 - 9.29 kg were purchased in Oyo State. The animal pens were disinfected and fumigated in preparation for the experiment. The pens were marked for identification of the different treatments and replicates. The concrete floor of the pen was covered with wood shavings. The animals were quarantined and treated with Oxytetracycline LA at 1/ml/10/kg weight and treated against ecto and endo parasites with Ivermectin at 1/ml/25kg weight. After, the sheep were allowed to acclimatize for two weeks; they were weighed, tagged and randomly allotted into three treatments with five replicates per treatment. Water was supplied *ad-libitum* throughout the period of the study which lasted for 63 days. Relevant management practice was

carried out when needed according to Baiden et al., (2007).

### Experimental design

Experimental design was completely randomized design of 3 treatments with 5 replicates per treatment.

### Experimental diets

The animals were offered the same feed (*Panicum maximum*) and supplementary concentrate diet at different delivery times.

The experimental diet layout is as follows -:

Treatment 1: *Panicum maximum*+ Supplemental diet (All at 0800 hours) Control

Treatment 2: *Panicum maximum* (0800 hours) + Supplemental diet (1 hour later)

Treatment 3: *Panicum maximum* (1600 hours) + Supplemental diet (1 hour later)

The experimental diets were both offered to the animals at 5% body weight per animal

The experiment lasted for 63 days

### Feed Intake and Weight gain

Daily records of feed intakes were taken by weighing the feed offered and the leftover after 24 hours. The daily intake of feed was estimated for each animal by subtracting the feed leftover from the quantity offered to the individual animals. Weight of individual animals was measured at the onset of the trial after an overnight fasting by withdrawing their feed and water from 7.00 pm to 8.00 am to obtain their initial weights and subsequently at 2 weeks intervals throughout the feeding trial. Weight gain was determined by subtracting the initial weight from the final weight within the feeding period.

### Digestibility Trials

Digestibility study was conducted after the feeding trial, five sheep were adapted in the metabolic cage for seven days, faeces and urine were collected for five days. Faeces and urine from individual animals, total fecal output was measured daily using a weighing scale, the faeces were bulked and at the end of the collection period 10% sub samples were dried, milled and stored in sealed and labeled bottle before analysis.

### Fecal and Urine collection

During digestibility trial Oluwadele et al., (2024c), daily samples of urine samples were collected and 10% of the sample (Aliquot) were collected. The fecal samples were preserved in a freezer at -18°C as well as urine except with the addition of a few drops of concentrated H<sub>2</sub>SO<sub>4</sub> to the urine. Samples were collected, the oven dried, milled and stored for chemical analysis while the aliquots for the urine was

kept in the freezer. The samples were tempered before being used for nitrogen determination. Apparent digestibility was obtained (AD) with this equation

$$\frac{\text{Nutrient intake} - \text{Nutrient in feces}}{100} \times \text{Nutrient intake}$$

### Chemical Analysis

Samples of the feeds and feces were dried in the oven at 105°C until constant weights were obtained to determine dry matter content. The feed samples were dried at 65°C for 12 hours and milled for proximate analysis using AOAC (1990). The fiber fractions: Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF) and Acid Detergent Lignin (ADL) were determined according to Van Soest et al., (1991)

### Nitrogen Retention

Nitrogen retention refers to the balance of nitrogen intake and excretion in animals, indicating the efficiency of dietary protein utilization. It is a critical metric for evaluating growth, reproduction, and overall productivity. High nitrogen retention signifies efficient feed protein use, reducing nitrogen waste and promoting sustainability in livestock production systems

Nitrogen retention (NR) can be calculated using the following formula:

$$\text{NR} = \text{N intake} - (\text{N feces} + \text{N urine})$$

Where:

N<sub>intake</sub>} N intake is the total nitrogen consumed through feed.

N<sub>feces</sub>} N feces is the nitrogen excreted in feces.

N<sub>urine</sub> is the nitrogen excreted in urine.

Nitrogen retention reflects the animal's ability to utilize dietary protein effectively, contributing to growth and productivity.

### Statistical Analysis

Data collected were subjected to Analysis of variance (ANOVA) using SAS package (SAS, 1997) and a treatment mean of separation using Duncan Multiple Range Test at  $\alpha_{0.05}$ .

## 3. RESULTS AND DISCUSSION

The study investigated the impact of feed delivery timing on the performance and nutrient metabolism of West African Dwarf (WAD) sheep, revealing significant findings across parameters of growth, feed intake, and nitrogen retention.

**Chemical Composition:** The nutritional composition analysis (Table 2) showed that the supplement had

nearly double the crude protein content (15.00%) compared to *Panicum maximum* (8.00%). This disparity significantly influenced nitrogen intake and retention. Similarly, higher crude fiber and neutral detergent fiber (NDF) in *Panicum maximum* could explain its slower digestibility, as observed in Table 4. (Tawose et al., 2023 and Oluwadele et al., 2024d)

**Performance Characteristics:** Performance results (Table 3) demonstrated significant differences in final body weight and daily weight gain among treatments. T1 (simultaneous feeding) and T3 (evening supplementation) showed superior performance compared to T2 (morning supplementation). The higher weight gains in T1 (4.92 kg) and T3 (4.95 kg) can be linked to better synchronization of nutrient supply with digestion patterns and rumen microbial activity. T2, with a lower weight gain (2.34 kg), might have suffered due to suboptimal nutrient availability during peak digestion Oluwadare et al., 2024a; Oluwadare et al., 2024b; Oluwadare et al., 2024c; Oluwadare et al., 2024d.

**Nutrient Digestibility and Intake:** Daily dry matter intake (DMI) was highest in T3 (566.38 g), followed by T1 (546.04 g), with T2 recording the lowest (527.89 g). This pattern mirrors the growth performance data (Oluwadele et al., 2023; Oluwadele et al., 2024b and Oluwadele et al., 2024c). Digestibility percentages also highlight the efficiency of T3 (80.91%), suggesting that evening supplementation aligns with improved nutrient absorption and metabolism.

**Nitrogen Metabolism:** Nitrogen retention was highest in T3 (2.73 g/day), followed by T1 (2.39 g/day), and lowest in T2 (2.22 g/day). The higher nitrogen retention in T3 is indicative of efficient protein utilization, likely due to better alignment of supplementation timing with rumen fermentation cycles. These findings correlate with previous studies (Akinlolu et al., 2018) showing the importance of feed timing in optimizing nitrogen utilization.

**Implications and Recommendations:** The results suggest that evening supplementation (T3) is most effective for enhancing growth performance and nutrient metabolism in WAD sheep. This feeding strategy leverages natural circadian rhythms to maximize nutrient absorption and utilization, consistent with findings from Fadiyimu et al. (2010). Future research could expand on these findings by evaluating long-term effects on reproductive performance and carcass quality.

#### 4. CONCLUSION

Feed delivery timing plays a crucial role in the growth and metabolic efficiency of WAD sheep. Evening supplementation (T3) emerged as the optimal strategy, underscoring the need for strategic feeding schedules to enhance productivity.

#### 5. CONFLICT OF INTEREST

All authors have declared that there is no conflict of interest regarding the publication of this article.

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**Table 1. Gross composition of Supplemented diet consumed by WAD Sheep**

Ingredients	Composition (%)
Cassava peel	53.0
BDG (Brewer's Dried Grain)	10.0
Groundnut haulms	20.0
PKC (Paim kernel Cake)	11.0
Urea	1.0
DCP (Dicalcium Phosphate)	2.0
Limestone	1.0
Grower's Premix	1.0
Salt	1.0
Total	100.0
Calculated crude protein	13.30

Energy Source: Metabolizable Energy (ME) is derived from cassava peel, PKC, and brewer's dried grain, calculated to meet the dietary requirement for WAD sheep (approximately 10-11 MJ/kg). Grower's Premix: Vitamin Components: Vitamin A: 10,000 IU/kg, Vitamin D3: 1,500 IU/kg, Vitamin E: 30 IU/kg. Minerals: Calcium: 2% (from limestone and DCP), Phosphorus: 0.5% (from DCP), Trace minerals: Zinc (80 mg/kg), Copper (8 mg/kg), Selenium (0.3 mg/kg), and Manganese (40 mg/kg)

**Table 2. Chemical composition of the experimental feed consumed by WAD sheep**

Parameters (%)	Supplement	( <i>Panicum maximum</i> )
Dry matter	92.00±0.03	93.50±0.37
Crude protein	15.00±0.03	8.00±0.03
Ether Extract	4.00±0.16	0.70±0.01
Crude fiber	27.00±0.03	30.00±0.03
Neutral detergent fiber	68.00±0.06	60.00±0.06
Acid detergent fiber	48.00±0.19	38.50±0.01
Ash	14.00±0.18	9.00±0.08
Organic Matter	71.00±0.23	69.00±0.23
Acid Detergent Lignin	25.00±0.11	7.00±0.06
Nitrogen Free Extract	45.00±0.06	31.00±0.03

**Table 3. Performance characteristics of WAD Sheep fed at different delivery times**

Parameters	Dietary Treatments			SEM
	T1	T2	T3	
Initial Body Weight (Kg)	8.26	9.29	8.81	0.31
Final Body Weight (Kg)	13.54 <sup>a</sup>	12.63 <sup>b</sup>	13.75 <sup>a</sup>	0.29
Weight gain (Kg)	4.92 <sup>a</sup>	2.34 <sup>b</sup>	4.95 <sup>a</sup>	0.42
Daily Weight gain (g)	78.06 <sup>a</sup>	37.21 <sup>b</sup>	78.51 <sup>a</sup>	0.67
Total Supp Intake (g)	10494.7 <sup>b</sup>	12119.94 <sup>a</sup>	11853.93 <sup>a</sup>	321.22
Total grass Intake (g)	12868.24 <sup>b</sup>	14669.27 <sup>a</sup>	15272.95 <sup>a</sup>	0.53
Total feed Intake (g)	23362.96 <sup>b</sup>	26789.29 <sup>a</sup>	27126.88 <sup>a</sup>	727.55
Daily feed Intake (g)	370.84 <sup>b</sup>	425.23 <sup>b</sup>	430.59 <sup>a</sup>	11.55
Feed Conversion ratio	5.60 <sup>b</sup>	11.73 <sup>a</sup>	5.50 <sup>b</sup>	0.95

Means in the same row with no superscript are not significantly different ( $p>0.05$ ); a,b,c: Means in the same row with different superscript are significantly different ( $p<0.05$ ); SEM: Standard error of the means, T1 =Animal fed with

## Growth and Nitrogen Use in WAD Sheep by Feed Timing

Grass and supplemented diet at the same time, T2= Animal fed with *Panicum maximum* (0800 hours) + Supplemental diet (1 hour later), T3 = Animal fed *Panicum maximum* (1600 hours) + Supplemental diet (1 hour later), suppl. TFI= 44.9%, TFI<sub>grass</sub> = 55.1%, TFE =100%

**Table 4. Intake and output of West Africa dwarf sheep fed at different delivery times**

Digestibility (%)	Treatments			
	T1	T2	T3	SEM
Daily Dry Matter Intake Supp diet(g)	242.95	230.79	253.80	8.55
Daily Dry Matter Intake Grass (g)	303.08	297.14	312.52	10.13
Daily Dry Matter Intake Feed (g)	546.04	527.89	566.38	18.54
Dry Matter Output (g)	567.14	663.04	540.82	26.22
Daily Dry Matter Output (g)	113.43	132.61	108.16	5.24

Means in the same row with no superscript are not significantly different ( $p>0.05$ ); a,b,c: Means in the same row with different superscript are significantly different ( $p<0.05$ ); SEM: Standard error of the means, T1 =Animal fed with Grass and supplemented diet at the same time, T2= Animal fed with *Panicum maximum* (0800 hours) + Supplemental diet (1 hour later), T3 = Animal fed *Panicum maximum* (1600 hours) + Supplemental diet (1 hour later) Total dry matter intake (100%), Grass DMI= 55.1%, Suppl. TFI= 44.9%

**Table 5. Nitrogen Metabolism of WAD Sheep at different delivery times.**

Parameters	T1	T2	T3	SEM
Nitrogen Intake grass(g/day)	2.64	2.58	2.72	0.09
Nitrogen Intake supp (g/day)	1.02	0.97	1.06	0.04
Nitrogen Intake feed (g/day)	3.66	3.55	3.78	0.12
Nitrogen output faeces (g/day)	1.27	1.33	1.05	0.06
Daily Urine voided (ml/day)	0.24	0.28	0.23	0.01
Urinary Nitrogen(g/day)	1.00	0.90	1.07	0.51
Nitrogen Concentration in urine Output(g/day)	0.024	0.005	0.002	0.0001
Nitrogen retention	2.39	2.22	2.73	0.15

Means in the same row with no superscript are not significantly different ( $p>0.05$ ); a, b, c: Means in the same row with different superscript are significantly different ( $p<0.05$ ); SEM: Standard error of the means, T1 =Animal fed with Grass and supplemented diet at the same time, T2= Animal fed with *Panicum maximum* (0800 hours) + Supplemental diet (1 hour later), T3 = Animal fed *Panicum maximum* (1600 hours) + Supplemental diet (1 hour later) TNI from grass= 72.1% and TNI from suppl.= 27.8%, total nitrogen intake 3.66 g= 100%