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Nutrient utilisation and growth response of *Balami* rams fed hydroponic sorghum fodder varieties with supplement

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ABSTRACT: A study was conducted to evaluate the growth performance, nutrient intake, nutrient digestibility and nitrogen balance in twenty (20) growing *Balami* rams fed four varieties of hydroponic sorghum fodder (HSF) with a supplemented concentrate diet. The HSF varieties were Red Chakalari (V1), White Chakalari (V2), Kaura (V3) and Jigari (V4). Results revealed significant ($p<0.05$) differences in all the nutrient intake parameters, with rams fed V4 (Jigari) showing the highest values except for organic matter intake. Weight gain and feed conversion ratio also differed significantly ($p<0.05$) among treatments, with rams on the Jigari variety achieving the highest weight gain of 142.28g/animal/day and the most efficient feed conversion. Although nutrient digestibility did not differ significantly ($p>0.05$), crude protein digestibility ranged from 79.37% (V4) to 82.04% (V1). Nitrogen balance showed significant ($p<0.05$) variations in nitrogen intake, faecal and urinary nitrogen output, and retained nitrogen across the treatments, with all groups having positive retained nitrogen as a percentage of intake. It was concluded that the Jigari variety of hydroponic sorghum fodder yielded the best performance in terms of growth, nutrient intake, and nitrogen utilisation in *Balami* rams.

Keywords: *Balami* rams, digestibility, hydroponic sorghum fodder, nitrogen balance, nutrient intake.

INTRODUCTION

Small ruminants form an integral and important component of the animal production system in most rural communities (Devendra, 2005). Sheep and goats are widely distributed in Nigeria, both in rural and urban areas, representing about 63.7% of total grazing domestic animals in the country (Gefu, 2002). The National Agricultural Sample Survey indicated that Nigeria is endowed with an estimated 19.5 million cattle, 72.5 million goats, 41.3 million sheep, 7.1 million pigs and 28 thousand camels (FAO,1992), and their role is extremely important within most farming systems, as they have the potential for capital accumulation (Gefu, 2002).

The unavailability of feed for ruminant animals during the long dry season in the Sudano-Sahelian zone, the traditional home of most of Nigeria's ruminant animals, is a major constraint to livestock production. During this period, available feeds are dry, the protein content is low, and there is a marked decrease in voluntary intake and digestibility (Abubakar *et al.,* 2006), making supplementation necessary to improve the nutrition of the animals. Improvement in the weight of ruminant animals fed poor-quality feeds can be achieved through protein supplementation of oilseeds.

The interest in the value of small ruminants as domestic livestock is widespread and is stimulated by an extensive recognition of their role in food production (Devendra, 2005). Hooft *et al.* (2008) also reported that the goal of livestock rearing is to attain self-sufficiency in their production and products. However, the unavailability of grazing feedstuffs remains one of the major problems of livestock production, particularly for ruminants (Jehsan, 2012, as cited in Ikwueze *et al.,* 2018). This problem can be alleviated by the introduction of modern techniques in livestock feed production, such as hydroponic fodder production (Jehsan, 2012, as cited in Ikwueze *et al.*, 2018), which involves the germination of seeds sprouted into high-quality, nutritious, and contaminant-free animal feed within a short period of time (Naik, 2013, as cited in Naik *et al*., 2015).

The use of hydroponic fodder production ensures the availability of high-quality fodder throughout the year and enhances the sustainability of ruminant production (Mooney, 2005; Naik, 2013, as cited in Naik *et al*., 2015). Therefore, the current study was designed to investigate the growth performance, nutrient intake, digestibility and nitrogen balance of *Balami* rams fed varieties of hydroponically grown sorghum fodder with supplement.

MATERIALS AND METHODS

Study area

The experiment was carried out at the Livestock Teaching and Research Farm, University of Maiduguri, Borno State. Maiduguri is situated at a latitude of 11°51'N and longitude 13°09'E at an altitude of 354 meters above sea level (Encarta, 2007), which falls within the semi-arid zone of West Africa. The area is characterised by a short period of rainy season (3-4 months) from June to September with annual rainfall ranging from 500 to 600 mm (Biu *et al.,* 2012). A Long dry season (8-9 months) from October to May is also observed annually. Ambient temperatures are high (38-44°C) during March to May, whereas low temperatures were recorded in December and January, ranging from 15-19°C (Weather and climate, 2020). Relative humidity is low in March (30%) and high in August (80%) (Biu *et al.*, 2012).

Hydroponic fodder production

A hydroponic unit was constructed at the Livestock Teaching and Research Farm, University of Maiduguri and installed in a growth room. The growth room was constructed with a cemented floor, netted walls and a roof made of aluminium sheets. It was surrounded by trees, which provided additional cooling and ventilation.

The unit consisted of a metal frame with dimensions of 3.5 meters in length, 1.5 meters in height and 0.75 meters in width, comprising four shelves. Each shelf contained seven (7) aluminium planting trays. The trays measured 70cm in length, 45cm in width and 6cm in depth. Holes were made at the bottom of each tray to allow drainage of excess water, thereby preventing waterlogging.

Planting materials used included trays, a knapsack sprayer, watering cans, buckets and four varieties of sorghum seeds for fodder production. The sorghum varieties used were Red Chakalari, White Chakalari, Kaura and Jigari, which are commonly grown in the research area due to their adaptability and affordability. The seeds were purchased from the Gamboru market in Maiduguri and were sorted for viability and quality to ensure better production.

A seed rate of 800 g per tray was used, corresponding to the capacity of the planting trays. The seeds were cleaned of debris and foreign materials, weighed and washed thoroughly with clean water. They were then soaked in water for 24 hours and rinsed again before planting. This process facilitated metabolism and utilisation of stored nutrients in the seeds, supported early plant development of the plant, and softened the seed coat for easier germination.

The soaked sorghum seeds were sown in trays without soil and manually irrigated using a knapsack sprayer and a watering can. The knapsack sprayer was used during the early stage of planting (1 to 3 days) to prevent scattering of seed in the trays. The trays were then stacked on the shelves and irrigated twice daily (morning and evening) to maintain adequate moisture for seedling growth. Fodder was harvested on the eighth day after planting and fed to the rams as a basal diet.

Supplement diet

A supplement diet was formulated consisting of maize bran, cotton seed cake, bone meal and salt. The maize bran and cotton seed cake were included at a ratio of 60:40 and were provided at a rate of 300g per animal per day. The ingredient composition of the supplement diet is presented in Table 1.

Experimental animals and their management

The experiment was conducted using twenty (20) growing *Balami* rams aged between 6 to 7 months with an initial body weight of 20±1kg. The rams were purchased from the Maiduguri Livestock Market. Each animal was identified using alphabet tags hung around their necks. The animals were quarantined for three weeks and monitored for any health problems. During the quarantine period, a broad spectrum dewormer (Albendazole tablets) was administered orally to control internal parasites, while Ivermectin (1ml/10kg body weight) was given subcutaneously to treat ecto-parasites. The rams were also injected with long-acting oxytetracycline (1 ml/10kg body weight) for protection against harmful microorganisms, and a multivitamin injection (1ml/5kg body weight) was administered intramuscularly to stimulate appetite. Additionally, Peste des Petits Ruminante (PPR) vaccine was administered for protection against PPR disease. During the quarantine period, the animals were gradually introduced to the experimental diets to allow adaptation prior to the commencement of the study.

Experimental design

The animals were randomly assigned to four treatment groups, with five replicates per treatment, in a Completely Randomised Design (CRD). On the 8th day, hydroponically

Table 1. Ingredients and percentage composition of the supplement diet.

Ingredients	Quantity
Maize bran	58.50
Cotton seed cake	39.00
Bone meal	02.00
Salt	00.50
Total	100.00

grown sorghum fodder varieties were offered as basal diets *ad libitum,* along with 300 g of a uniform supplement provided to each ram daily.

Experimental procedure and feeding

Twenty (20) *Balami* rams were individually weighed and randomly assigned to four treatment groups with five rams per group, in a Completely Randomised Design (CRD). The animals were housed individually in separate pens, each equipped with feeders and drinkers, and the pens were swept daily to maintain hygiene. Each treatment group was assigned one variety of hydroponic sorghum fodder (HSF) as a basal diet, offered without restriction. In addition, each ram received 300g of supplement daily. The daily rations were divided into two equal portions and fed in the morning and evening hours at approximately 700 and 1600 hours, respectively. The feeding trial lasted for a period of 10 weeks.

Data collection

A known quantity of feed was given daily, and the leftover was weighed to determine the feed intake for each ram using the formula: feed intake = total feed given – leftover. The body weight of each animal was recorded at the onset of the experiment and subsequently every week throughout the study period. The feed conversion ratio is the total feed intake divided by the body weight gain.

Apparent nutrient digestibility and nitrogen balance

Apparent nutrient digestibility was determined at the end of the feeding trial using metabolism cages. Twelve animals were randomly selected (three from each treatment group) and placed in individual metabolic cages. The animals were given a 14-day adjustment period in the cages, after which data on total feed intake, faecal output and urine output were collected from each animal over 7 days. Samples of faeces and urine were collected, air-dried, bulked and sub-sampled for chemical analysis. For urine samples, concentrated hydrochloric acid was added to prevent evaporation and caking. Nutrient digestibility and nitrogen retention were determined using the formula:

$$\mathrm{AND} = \frac{\text{Nutrient intake} - \text{Nutrient in faeces}}{\text{Nutrient intake}} x100$$

$$\mathrm{NR} = \frac{\text{Nitrogen Intake} - (\text{Faecal} + \text{Urinary Nitrogen})}{\text{Nitrogen Intake}} x100$$

Where: AND = Apparent Nutrient digestibility, and NR= Nitrogen Retention.

Chemical analysis

Samples of the diets and faeces were collected and analysed on a dry matter (DM) basis for crude protein (CP), ether extract (EE), crude fibre (CF) and ash content according to AOAC (2010). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined using the method described by Van Soest *et al.* (1991). Organic matter (OM) and nitrogen free extract (NFE) were calculated accordingly.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) in a Completely Randomised Design (CRD) using the General Linear Model (GLM) procedure of SAS (2000), and treatment means were separated using the Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

The chemical compositions of basal (four varieties of HSF) and supplement diets are presented in Table 2. The dry matter (DM) content of the basal diets ranged from 12.10 to 16.35%, while the supplement diet had 93.33% DM. Organic matters were 11.10, 14.45, 15.35, 13.00 and 82.49% for V1, V2, V3, V4 and the supplement diet, respectively. The crude protein (CP) of the fodder ranged from 9.31 to 14.05% with V4 having the highest value. Similarly, the supplement diet had a crude protein value of 31.52%. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were highest in V4 recording, 44.36% and 30.86%, respectively. The lowest values of NDF (36.08%) and ADF (19.36%) were observed in the supplement diet.
The dry matter contents of the basal fodder (four HSF varieties) compared favourably with Super-1 HSF (14.55%) harvested at 12 days and KD4 HSF (15.68%) harvested at 16 days (Christidiana, 2018), but were lower than that of hydroponic maize fodder (18.30%) harvested at 8th day harvest (Naik, 2014). Al-Karaki and Al-Momani (2011) reported 12.2% DM for barley hydroponic fodder harvested at 10 days, which was similar to the value for Red Chakalari HSF but lower than the other varieties used in this study. Generally, the decrease in DM content of hydroponic fodder is attributed to a reduction in starch content due to water imbibition. The DM content for the supplements in this study was within the range reported by

Table 2. Chemical composition (%) of basal (HSF varieties) and supplement diets.

Nutrients	V1	V2	V3	V4	SUPP
DM	12.10	15.95	16.35	14.50	93.33
OM	11.10	14.45	15.35	13.00	82.49
CP	11.71	10.62	09.31	14.05	31.52
ASH	01.00	01.50	01.00	01.50	10.84
EE	01.00	01.00	01.50	01.00	07.80
NDF	43.15	40.75	38.12	44.36	36.08
ADF	29.04	25.85	22.20	30.86	19.36

HSF = Hydroponic Sorghum Fodder, DM = Dry Matter, OM = Organic Matter, CP = Crude Protein, EE = Ether Extract, CF = Crude Fiber, ADF = Acid Detergent Fiber, NDF = Neutral Detergent Fiber, V1 = Red Chakalari Variety, V2 = White Chakalari Variety, V3 = Kaura Variety and V4 = Jigari Variety, SUPP= Supplement.

Table 3. Growth performance of growing *Balami* rams fed different varieties of hydroponic sorghum fodder with supplement.

Parameters	Treatments				SEM	LS
	V1	V2	V3	V4		
Basal Feed Intake (g/day)	1365.4^{ab}	1364.0^{ab}	1329.6^{b}	1460.8^{a}	52.43	*
Supplement Intake (g/day)	274.93	272.14	260.03	279.61	12.14	NS
Total Feed Intake (g/day)	1640.33^{ab}	1636.14^{ab}	1589.63^{b}	1740.41^{a}	63.69	*
Total DM Intake (g/day)	762.23^{b}	796.53^{ab}	783.33^{ab}	803.65^{a}	18.86	*
Initial Weight (kg)	22.80	22.00	22.00	22.40	01.14	NS
Final Weight (kg)	31.20^{ab}	28.80^{b}	29.80^{ab}	32.40^{a}	1.37	*
Total Weight Gain (kg)	08.40^{ab}	06.80^{b}	07.80^{b}	10.00^{a}	1.01	*
Daily Weight Gain (g/day)	120.00^{ab}	97.14^{b}	111.43^{b}	142.86^{a}	14.43	*
Feed Intake Per % Body Weight	05.26	05.68	05.33	05.37	0.82	NS
Feed Conversion Ratio	06.50^{b}	08.94^{a}	07.21^{ab}	05.69^{b}	1.11	*

V1 = Red Chakalari, V2 = White Chakalari, V3 = Kaura and V4 = Jigari, SEM = Standard Error of Mean, LS = Level of Significance, * = ($p<0.05$), ^{a,b,c,d} = Means in the same row with different superscripts are significantly different, NS = Not Significant.

many authors, such as 92.98 to 94.61% for various nitrogen supplements fed to rams (Abubakar *et al.,* 2012). Chana *et al.* (2017) reported DM values ranging from 92.50 to 93.23% for graded levels of sorrel seed meal supplementation.

The crude protein content of HSF varieties observed in the present study, ranging from 9.31 to 14.05% was adequate for ruminant feeding. The CP values increased with a corresponding decrease in DM and OM, aligning with the values reported in most hydroponic fodder studies. Naik *et al.* (2015) reported ~~a~~ CP content ranging from 8.88 to 13.57% hydroponic maize, while higher CP values were reported by Christidiana (2018) and Al-Karaki and Al-Momani (2011) for hydroponic sorghum and barley, respectively. These differences may be due to seed variation, type of hydroponic unit, growth room conditions (greenhouse), irrigation frequency, nutrient supply, and location. The higher CP in the diet suggests it could compensate for any deficiency in the basal diet. The NDF and ADF levels for both the basal and supplement diets were low, indicating better feeding quality since they were all below the 55 to 60% threshold known to limit feed intake and growth performance of ruminants (Meissner *et al.,* 1991).

Growth performance

The growth performance of growing *Balami* rams fed different varieties of HSF with supplements is presented in Table 3. The results indicated a significant ($p<0.05$) difference in basal feed intake, with rams in treatment 4 (V4) recording the highest value (1460.8 g/day), while treatment 2 (V2) had the lowest (1364 g/day). No significant ($p>0.05$) difference was observed in supplement feed intake. Mean total DM intake ranged from 762.23 g/day (V1) to 803.65 g/day (V4), showing a significant ($p<0.05$) difference among the treatments. All groups started with similar initial weights, but final live weights varied significantly ($p<0.05$). Live weight gains

Table 4. Nutrient Intake of *Balami* Rams Fed Varieties of HSF with Supplement Diet.

Nutrients	Treatments				SEM	LS
	VI	V2	V3	V4		
DMI (g/day)	762.23^{b}	796.53^{ab}	783.33^{ab}	803.65^{a}	18.86	*
OMI (g/day)	586.20^{c}	590.18^{bc}	599.54^{a}	595.77^{ab}	3.82	*
CPI (g/day)	136.36^{b}	135.44^{b}	137.97^{b}	145.41^{a}	2.13	*
NDFI (g/day)	295.9^{b}	296.18^{b}	315.8^{a}	318.27^{a}	5.67	*
ADFI (g/day)	164.25^{b}	159.03^{b}	176.01^{a}	182.33^{a}	3.40	*

HSF = Hydroponic Sorghum Fodder, DMI = Dry Matter Intake, OMI = Organic Matter Intake, CPI = Crude Protein Intake, NDFI = Nitrogen Detergent Fibre Intake, ADFI = Acid Detergent Fibre Intake, V1 = Red Chakalari Variety, V2 = White Chakalari Variety, V3 = Kaura Variety and V4 = Jigari Variety, SEM = Standard Error of Mean, LS = Level of Significance, * = ($p<0.05$), ^{a,b,c,d} = Mean in the same row with different superscripts are significantly different.

were 120, 97.14, 111.43 and 142.86 g/day for rams in V1, V2, V3 and V4 groups, respectively, with V4 recording the highest gain and V2 the lowest. Feed intake as a percentage of body weight was not significantly ($p>0.05$) different, but higher percentages were obtained because the basal feed contained more moisture. A significant ($p<0.05$) difference was observed due to the moisture content of the basal diets. Feed conversion ratio (FCR) differed significantly ($p<0.05$) among the treatments. Rams fed V4 (5.69) had the best feed conversion ratio, indicating better feed efficiency, followed by V1 (6.5), V3 (7.21) and V2 (8.94). The ranking order for FCR was V4>V1>V3>V2. The result of this study agreed with the outcome of Seid *et al.* (2025), who reported an increase in growth performance of sheep fed effective microorganism (EM)-treated *teff* straw, with varying concentrate levels. The study shows higher dry matter intake, body weight gains and feed conversion efficiency in sheep fed (EM)-treated *teff* straw with the highest concentrate levels. The present result of this study is also in agreement with the result of Idan *et al.* (2023), indicating an increase in growth performance of sheep fed rice straw with two fodder tree leaves and their combinations.

The nutrient intake

The nutrient intake of growing *Balami* rams fed four varieties of HSF with supplements is presented in Table 4. There was a significant ($p<0.05$) difference in all nutrient intake parameters across treatments. Rams fed treatment 4 (Jigari variety + supplement) had the highest dry matter intake (803.65 g/day), while those fed Red Chakalari + supplement had the lowest (762.23 g/day). Organic matter intake was highest in V3 (599.54g/day) and lowest in V1 (586.20 g/day). Crude protein intake (CPI) values were 136.36, 135.44, 137.97 and 145.41 g/day for V1, V2, V3 and V4, respectively. V4 had the highest CPI, while V2 had the lowest. Neutral detergent fibre intake was significantly higher in V4 (318.27 g/day) and lowest in V2 (295.9 g/day). Acid detergent fibre intake also differed significantly ($p<0.05$) among treatments, ranging from 59.03 to 183.33 g/day. The results of this study conform with the results reported by Yerima *et al.* (2022), who show that Yankasa sheep fed sorghum stover based diet containing urea at 1% and cottonseed cake at 10% level of inclusion gave higher significant ($p<0.05$) difference with the other treatments and have the better growth performance, feed conversion ratio and economics of production. However, the values for all the parameters of nutrient intake in this study are lower than the values obtained by Yerima *et al.* (2022) and Seid *et al.* (2025).

Apparent nutrient digestibility

Apparent nutrient digestibility results are presented in Table 5. There was no significant ($p>0.05$) difference among rams fed different HSF varieties for any of the nutrients. Dry matter digestibility was highest in V3 (51.78%), followed by V2 (51.56%), V1 (48.65%) and lowest in V4 (45.22%). Organic matter digestibility ranged from 41.81% (V2) to 33.43% (V4). Crude protein digestibility values of 82.04, 81.75, 81.03 and 79.37% for V1, V2, V3, and V4, respectively, with no significant difference ($p>0.05$). NDF and ADF digestibility were highest in V2 (49.45% and 45.44%, respectively). The lowest NDF digestibility was recorded in V4 (45.46%), and the lowest ADF digestibility was in V3 (40.70%). The digestibility values obtained in the current study are lower than the values recorded by Seid *et al.* (2025) and Yerima *et al.* (2022), but the crude protein digestibility was higher than the range of 52.6 to 77.4% obtained by Idan *et al.* (2023). However, this might be attributed to its low dry matter content in all the varieties of HSF since they are all tender fodder, but nevertheless, its high protein content augments its nutrient value. Higher values of CPD (92.75 to 95.87%) were reported for Awassi lambs fed green alfalfa substituted with hydroponic fodder barley (Tawfeeq *et al.,* 2018), who stated that highly non-structured carbohydrates and a low proportion of ash lead to an increase digestibility of nutrients with increasing hydroponic in treatments (Tawfeeq *et al.,* 2018). Lower digestibility of fibre fraction (NDF and ADF) was recorded,

Table 6. Nutrient digestibility (%) of growing *Balami* rams fed varieties of hydroponic sorghum fodder with supplement.

Parameters	Treatments				SEM	LS
	V1	V2	V3	V4		
Dry Matter Digestibility	48.65	51.56	51.78	45.22	7.28	NS
Organic Matter Digestibility	39.15	41.81	40.94	33.43	9.39	NS
Crude Protein Digestibility	82.04	81.75	81.03	79.37	2.73	NS
NDF Digestibility	47.66	49.58	47.33	45.46	7.78	NS
ADF Digestibility	46.17	46.44	40.70	45.32	9.61	NS

ADF = Acid Detergent Fibre, NDF = Neutral Detergent Fibre, V1 = Red Chakalari, V2 = White Chakalari, V3 = Kaura and V4 = Jigari Variety, SEM = Standard Error of Mean, LS = Level of Significance, NS = Not Significant.

Table 6. Nitrogen balance of growing *Balami* rams fed varieties of hydroponic sorghum fodder with supplement**.**

Parameters	Treatments				SEM	LS
	V1	V2	V3	V4		
Nitrogen Intake (g/day)	65.96^{b}	66.03^{b}	66.92^{b}	72.59^{a}	1.19	*
Faecal Nitrogen (g/day)	3.92	3.98	4.19	4.80	0.66	NS
Urinary Nitrogen (g/day)	3.26	2.15	3.44	4.85	0.05	NS
Total Nitrogen Output (g/day)	7.18^{b}	6.12^{b}	7.63^{b}	9.66^{a}	0.66	*
Nitrogen Retained (g/day)	58.77^{b}	59.90^{b}	59.29^{b}	62.93^{a}	0.60	*
Nitrogen Retained (as % of intake)	89.10	90.71	88.60	86.70	8.17	NS

SEM = Standard Error of Mean, LS = Level of Significance, * = ($p<0.05$), ^{a,b,c,d} = Means in the same row with different superscripts are significantly different, NS = Not Significant.

which was a result of its lower content in their chemical composition of the diets.

Nitrogen balance

The nitrogen balance of rams fed four HSF varieties with supplements is shown in Table 6. Daily nitrogen intake (NI) was significantly ($p<0.05$) different among the groups. Rams fed V4 had the highest NI (72.59g/day) while those in V1 had the lowest (65.96g/day). Faecal and urinary nitrogen did not differ significantly ($p>0.05$) among the groups. However, daily nitrogen output showed a significant difference ($p<0.05$), with values of 7.18, 6.12, 7.63 and 9.66g/day for V1, V2, V3 and V4, respectively. Nitrogen retained (NR) values were significantly different ($p<0.05$) across the treatments, ranging from 58.77g/day (V1) to 62.93g/day (V4). However, nitrogen retention as a percentage of intake was not significantly ($p>0.05$) different, with values of 89.10, 90.71, 88.60, and 86.17% for V1, V2, V3, and V4, respectively. The results of this study differ from those reported by Idan *et al.* (2023). Here, nitrogen intake was much higher (65.96 to 72.59 g/day) while nitrogen output was relatively low (6.12 to 9.66 g/day). By comparison, Idan *et al*. (2023) found lower nitrogen intake (9.0 to 26.9 g/day) and a wider range of nitrogen output (2.75 to 26.9 g/day). These differences are likely due to the different types of feed used. The nitrogen balance in this study shows that both the basal and supplement diets were efficiently absorbed and retained.

Conclusion

It is concluded from the results of this study that hydroponic sorghum fodder produced from four different varieties, Red Chakalari, White Chakalari, Kaura, and Jigari, and harvested on the 8th day, demonstrated good fodder quality and yield. When fed to *Balami* rams alongside a concentrate supplement, it resulted in improved weight gain, enhanced nutrient digestibility, and better nitrogen balance. Among the varieties, the Jigari variety produced the best overall results in terms of growth performance and nutrient utilisation.

Recommendations

Based on the observations from this study, hydroponic sorghum fodder produced from the Jigari variety gave the best yield and nutrient contents as compared to other varieties, and when Jigari HSF with concentrate supplement was fed to *Balami* rams, it gave the best growth rate, nutrient intake and digestibility. Therefore, Jigari HSF with supplements is recommended for growing *Balami* rams.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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