World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

In Vivo Digestibility of Maralfalfa Forage (*Pennisetum sp*.) and Bush Straw by Sahelian Sheep

Hassan Ahmat Djefil [1, *], Oumar Moucthar Kodbe [2], Mahaman Malam Mouctari Ousseini [3], Mian Oudanang Koussou [1] and Chaibou Mahamadou [3]

[1] *Institute of Research in Livestock for Development (IRED), N'Djamena, Chad.*
[2] *Laboratory of Biology, Faculty of Exact and Applied Sciences (FSEA), University of N'Djamena, P.O. Box 1027, Chad.*
[3] *Department of Animal Production, Faculty of Agriculture, Abdou Moumouni University of Niamey, P.O. Box 10960, Niamey-Niger.*

World Journal of Advanced Research and Reviews, 2025, 28(02), 1804-1810

Publication history: Received on 11 August 2025; revised on 20 November 2025; accepted on 22 November 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.28.2.3920

Abstract

The aim of this study is to investigate the in vivo digestibility of Maralfalfa (*Pennisetum sp.)* forage and bush straw in Saharan sheep. The experiment involved twelve (12) ram lambs of the Peul bicolor breed, aged between 24 to 36 months and averaging 29±0.5 kg. The animals were divided into 3 groups of 4 based on live weight homogeneity criteria to minimize individual variations. They were individually placed in digestibility cages equipped with drinking, feeding, and feces and urine collection devices. Three different rations (Maralfalfa hay ration: MHR; bush straw ration: BSR; and Maralfalfa straw ration) were offered to all groups twice a day at a rate of 750 g in the morning and evening (8 a.m. and 6 p.m.) to meet their maintenance needs. Each group was exclusively subjected to one of the three rations. The study lasted 41 days, including 27 days of adaptation and 14 days of data collection. The main results show that the food intake of different forages in Saharan sheep was significant ($P<0.05$). The MHR ration had a higher consumption, followed by the BSR, while the MSR ration showed lower consumption. Nutrient intake was significant according to the rations ($P<0.05$). The MHR and BSR rations had higher contents of dry matter (DM), organic matter (OM), total nitrogenous matter (TNM), and neutral detergent fiber (NDF). The ADL content was higher in the BSR ration. Nutrient digestibility was significant according to the rations, except for the ADF utilization coefficient. The MHR ration achieved the best digestibility, followed by the BSR ration. A better nitrogen intake was obtained with the MHR ration, while high digestibility for urinary nitrogen and retained nitrogen was achieved with the BSR ration. The objective of this study is to determine the impact of Maralfalfa forage on the digestibility, nutritional quality, and zootechnical performance of sheep, in order to provide recommendations for its integration into Sahelian livestock systems

Keywords: Forages; Maralfalfa; Ration; Digestibility; Ram; Straw

1. Introduction

Livestock is a vital resource for Chad, housing nearly 94 million heads of cattle, primarily ruminants, according to the general census of the Ministry of Livestock and Animal Production (MEPA, 2015). In the Sahelian region, grazing is essential for feeding these animals (Akpo *et al.*, 2003). However, access to sufficient quantities and quality of forage and supplementary feed has become a strategic priority to secure pastoral and ago-pastoral livestock farming (Mian Danang *et al*., 2008).

It is crucial that diets, especially for ruminants, balance the "bulk" necessary to stimulate rumination with nutritional intake (Boulkhir, 2020). Nevertheless, despite their recognized importance, forage crops still occupy a marginal position

* Corresponding author: Hassan Ahmat Djefil

in the country's crop production (Agondangou, 2023). Although pure forage crops can produce significant biomass, their integration is often hindered by high labor demands, especially during periods when the agricultural calendar is already busy (Dugué *et al.,* 2012).

Since 2020-2021, a forage grass imported from Latin America, "Maralfalfa" (*Pennisetum sp.*), has been tested at the IRED experimental station in N'Djamena. This highly nutritious and abundantly productive plant has a considerable advantage: it propagates through cuttings, making it easier to establish than other grasses with low germination rates. This represents a valuable solution to the lack of grazing in arid areas like the Sahel (Richard *et al.,* 2019).

To optimize the use of this resource, it is essential to assess the effect of Maralfalfa forage (*Pennisetum sp*.) on biochemical parameters, particularly the energy and protein components of blood, through digestibility tests. Indeed, the nutritional value of forage depends not only on the quantity consumed but also on its energy value, with the digestibility coefficient of organic matter being a key indicator (Mostefai *et al.,* 2017). According to Djibril (2015), this information is crucial for assessing the nutritional quality of feed, as it reveals the extent of nutrient assimilation by the animal; low digestibility can lead to decreased livestock performance.

2. Materials And Methods

2.1. Plant Material

The plant material consists of forage from *Pennisetum sp.* (Maralfalfa) produced at the IRED experimental station and stored at the ACCEPT Project site in Farha (N'Djamena), along with bush straw purchased from Dromgoole village in the 1st Arrondissement of N'Djamena.

Two (02) rations were prepared from Maralfalfa forage: one ration made from hay of this forage cut at 45 days of age, dried in the shade, and then ground, and the other made from Maralfalfa straw aged over three (03) months, lignified in the field, then cut and left in the sun to dry before being ground. The third ration consists of bush straw for the control group.

The rations are presented as follows

- R1: Ration consisting of chopped Maralfalfa hay from cuts at 45 days (MHR)
- R2: Ration consisting of chopped Maralfalfa straw cut at over 3 months (MSR)
- R3: Ration consisting of chopped bush straw for natural feeding (BSR)

Figure 1 Sequentially, Maralfalfa hay ration, Maralfalfa straw ration, and control ration of bush straw

2.2. Animal Material

The animal material consists of twelve (12) bicolor rams of the Peulh breed, aged 24 to 36 months and weighing an average of 29±0.5 kg, purchased from the Ndjamena-Koura market, located southeast of the capital N'Djamena. The animals are housed in individual digestibility cages. They were weighed at the beginning and end of the adaptation phase, and then at the start, middle, and end of the data collection phase. The animals were tagged, vaccinated, and subjected to preventive treatments with long-acting Oxytetracycline 20% (1 ml/10 kg of body weight per animal via intramuscular injection) and internal and external deworming with Ivermectin 1% to enhance immunity and control parasites.

Figure 2 Sequentially, a ram used, samples of feces and urine

2.3. Study Area

The study was conducted from May 5 to June 14, 2023, at the ACCEPT Project site at the Institute of Research in Livestock for Development (IRED) in N'Djamena, Chad. The climate is Sahelian, with temperatures ranging from 18°C to 45°C. The rainy season extends from June to September, with average rainfall varying from 400 to 800 mm depending on the North-South gradient. The year consists of a dry season and a rainy season.

2.4. Experimental Design

The experiment involved twelve (12) bicolor rams of the Peulh breed, aged between 24 to 36 months and weighing an average of 29±0.5 kg. The animals were divided into 3 groups of 4 animals based on weight homogeneity criteria to minimize variation among individuals. They were individually housed in digestibility cages equipped with drinking devices, feeders, and collection systems for feces and urine. Three different rations (Maralfalfa hay ration: MHR, bush straw ration: BSR, and Maralfalfa straw ration: MSR) were provided to all groups twice a day, at 750 g in the morning and 750 g in the evening (8 a.m. and 6 p.m.) to meet their maintenance needs. Each group received only one of the three rations. The study lasted 41 days, including 27 days of adaptation and 14 days of data collection.

2.5. Group Composition and Ration Distribution

The twelve (12) rams were distributed into 3 groups of 4 animals based on weight homogeneity criteria to minimize individual variations. They were placed individually in metabolic cages equipped with drinking devices, feeders, and feces collection systems designed during their construction. These experimental devices allowed for measuring the exact quantities of food offered, ingested, and refused, as well as the collection of urine and feces. The three different rations were offered to the animals from the three groups twice a day, providing 750 g in the morning and 750 g in the afternoon to meet their maintenance needs. Each group was exclusively subjected to one of the three rations. The animals had ad libitum access to water.

2.6. Test Conduct and Data Collection

The chosen method for studying digestibility was the direct in vivo method, which offers advantages in terms of technical simplicity and reliability. The trial lasted forty-one (41) days, including a twenty-seven (27) day adaptation period that allowed the animals to acclimate to the rations and confinement, followed by a fourteen (14) day data collection phase. The death and replacement of two animals during the adaptation phase resulted in an extension of the trial. A few additional days were permitted to allow the digestive systems of the remaining animals to adjust to the experimental rations. During the data collection period, 150 g fecal samples per animal, as well as 100 g samples of offered and refused rations, were collected daily. These samples were weighed using an electronic scale with a capacity of 3000 g and a sensitivity of 1 g. They were then dried at 60 °C until a constant weight was obtained in a ventilated oven, in preparation for chemical composition analyses.

Urine was collected in a 5-liter container equipped with a tube placed under the metal cage. Thus, 20 ml of urine produced by each animal was collected daily in bottles that had been pre-treated with 10% diluted sulfuric acid (H_2SO_4) to stabilize urinary nitrogen. These urine samples were stored at 4°C in a refrigerator for nitrogen analysis.

2.7. Sample Preparation for Analyses

For the digestibility study of forages, 100 g of the rations and 150 g of feces were dried in an oven at 60 °C for 48 hours, then ground to a size of 1 mm at the Institute of Research in Livestock for Development (IRED). The results of the chemical composition analyses regarding dry matter, ash, organic matter, crude fiber, total nitrogenous matter, lipids, and urinary nitrogen excretion from the various rations and feces were performed using a Fourier Transform Infrared Spectrometer (FTIR).

The spectra of the fecal and ration samples were obtained using the FTIR at the IRED/ACCEPT Laboratory in N'Djamena, and their predictions were sent to and realized at the Montpellier Laboratory. The urine was analyzed at the Laboratory of the Chadian Institute of Agronomic Research for Development (ITRAD) in N'Djamena.

2.8. Statistical Analyses

The data on intake and digestibility of the rations were subjected to a two-factor analysis of variance (ANOVA), which included the forage conservation method and the forage harvest age, according to a general linear model in a completely randomized design. Means will be separated when significant differences occur at the 5% level. Statistical analysis will be performed using SPSS 21.0 software.

3. Results

3.1. *In Vivo* Digestibility of Different Forages in Sahelian Sheep

The food intake of different forages in Sahelian sheep was significant ($P < 0.05$). The MHR ration was the most consumed, followed by the BSR and MSR rations.

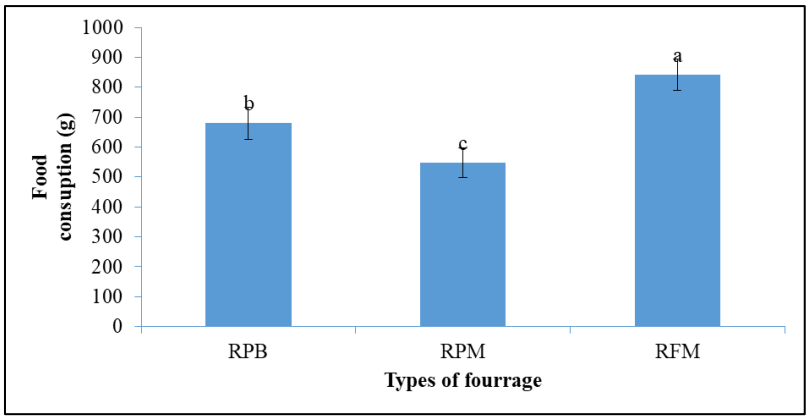

Figure 3 Food consumption of different forages in Sahelian sheep

3.2. Nutrient Ingestion from Different Forages in Sahelian Sheep

Table 1 presents the nutrient intakes from the different forages in sheep. Nutrient ingestion was significant across rations ($P < 0.05$). The MHR and BSR rations have higher contents of dry matter (DM), organic matter (OM), total nitrogenous matter (TNM), and neutral detergent fiber (NDF). The ADL content is higher in the MSR ration.

Table 1 Nutrient Ingestion from Different Forages in Sheep

Constituents (%DM)	Rations			P
	BSR	MSR	MHR	
DM	617,23±1,86^{b}	521,72±0,32^{c}	803,66±1,07^{a}	0,00
OM	505,04±4,52^{b}	481,24±4,47^{c}	673,78±5,35^{a}	0,00
TNM	39,49±0,87^{b}	20,26±1,46^{c}	74,87±2,27^{a}	0,00
CBW	192,81±3,39^{b}	251,36±6,84^{c}	305,59±2,46^{a}	0,00

NDF	384,34±4,02^{c}	432,71±8,61^{b}	572,28±3,54^{a}	0,00
ADF	273,93±6,05^{b}	278,07±7,29^{b}	319,13±4,85^{a}	0,00
ADL	79,47±1,30^{a}	54,86±3,86^{b}	25,29±1,25^{c}	0,00

BSR: Bush Straw Ration, MSR: Maralfalfa Straw Ration, MHR: Maralfalfa Hay Ration, DM: Dry Matter, OM: Organic Matter, TNM: Total Nitrogenous Matter, CB: Crude Fiber, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, ADL: Acid Detergent Lignin

3.3. Nutrient Digestibility from Different Forages in Sahelian Sheep

Table 2 presents the digestibility of nutrients from different forages in sheep. Nutrient digestibility was significant across rations, except for the ADF utilization coefficient. The MHR ration achieved the best digestibility, followed by the BSR ration.

Table 2 Nutrient Digestibility from Different Forages in Sheep

Constituents (%DM)	**Rations**			**P**
	BSR	MSR	MHR	
CUDA DM	90,85±0,43^{a}	87,11±0,74^{b}	91,77±0,32^{a}	0,00
CUDA OM	91,47±0,49^{a}	89,49±0,61^{b}	92,62±0,25^{a}	0,00
CUDA TNM	93,29±0,34^{a}	90,87±0,93^{b}	92,79±0,48^{a}	0,04
CUDA CBW	92,97±0,45^{b}	92,58±0,48^{b}	94,00±0,28^{a}	0,03
CUDA NDF	93,08±0,41^{a}	90,29±0,59^{b}	92,78±0,31^{a}	0,00
CUDA ADF	90,92±0,64^{a}	90,12±0,62^{a}	91,55±0,30^{a}	0,23
CUDA ADL	91,46±0,29^{a}	87,49±1,13^{b}	73,59±0,82^{c}	0,00

BSR: Bush Straw Ration, MSR: Maralfalfa Straw Ration, MHR: Maralfalfa Hay Ration

3.4. Nitrogen Ingestion and Digestibility from the Consumption of Different Rations in Sahelian Sheep

Table 3 presents the nitrogen ingestion and digestibility from different forages in sheep. Digestibility was significant depending on the rations ($P < 0.05$). The best nitrogen ingestion was obtained with the MHR ration. High digestibility of urinary nitrogen and retained nitrogen was observed with the BSR ration.

Table 3 Digestibility of Nutrients from Different Forages in Sheep

Constituents (%DM)	**Rations**			**P**
	BSR	MSR	MHR	
N Ingested	0,94±0,03^{b}	0,57±0,02^{c}	1,46±0,04^{a}	0,00
N Feces	0,61±0,02^{b}	0,36±0,02^{c}	1,14±0,02^{a}	0,00
N Urine	0,28±0,01^{a}	0,15±0,00^{c}	0,21±0,03^{b}	0,00
N RETEINED	0,34±0,02^{a}	0,03±0,01^{b}	0,10±0,00^{c}	0,00
CUDA N	6,36±0,20^{b}	10,33±0,22^{a}	6,93±0,19^{b}	0,00

BSR: Bush Straw Ration, MSR: Maralfalfa Straw Ration, MHR: Maralfalfa Hay Ration

4. Discussion

The results of this study reveal significant differences in nutrient intake and digestibility in sheep, particularly among the BSR (Bush Straw Ration), MSR (Maralfalfa Straw Ration), and MHR (Maralfalfa Hay Ration). These findings are essential for optimizing sheep nutrition in Sahelian regions, where the quality and availability of forages may vary. According to Sissao *et al.* (2024), the total nitrogen content in pre-dried Pennisetum pedicellate forage is 9.24%, while in silage it is 5.19%.

The BSR and MHR rations show higher coefficients for dry matter (DM) and organic matter (OM) utilization, indicating an increased ability of sheep to extract nutrients from these forages. This observation aligns with the work of Thumbed *et al.* (2001) and Numbi's *et al.* (2014), who emphasize that forage quality plays a crucial role in optimizing intake. For instance, Miege (2016) found that protein-rich forages like Maralfalfa significantly promote intake, a point also corroborated by Kouakou *et al.* (2016).

The MHR ration exhibits high digestibility of total nitrogenous matter, which is essential for the growth and production of sheep. This result is consistent with findings by As Soumaya *et al.* (2007), who noted that protein digestibility is often influenced by forage composition. Although ADF (Acid Detergent Fiber) digestibility shows no significant differences among the rations, the MHR ration displays a much lower utilization coefficient for ADL (Acid Detergent Lignin), suggesting better degradation of lignified compounds. The results obtained are similar to those of Bouckaert (2024), who highlighted that lignin can limit digestibility, making forage quality even more crucial. Furthermore, Alane *et al.* (2024) showed that in the Matida, four cultivars of Medicago sativa have an average digestibility of 66.99% at the floral bud stage, decreasing to 63.29% at the beginning of flowering.

The results indicate that nitrogen intake and digestibility vary significantly across rations ($P < 0.05$). The MHR ration led to a markedly higher nitrogen intake, indicating that sheep consume more protein from this forage. This finding corroborates the results of Cutuli *et al.* (2013) and Oumar *et al.* (2023), who demonstrated in their studies that protein-rich rations enhance nitrogen intake. However, nitrogen digestibility is significantly higher in the BSR ration, both for urinary nitrogen and retained nitrogen. This suggests that while MHR is attractive in terms of intake, BSR allows for better utilization of ingested proteins. Research by Klein *et al.* (2014) supports this observation, showing that higher-quality forages promote more effective nitrogen retention.

The Digestive Utilization Coefficient of Nitrogen (DUCN) is highest for the MSR ration, indicating superior efficiency in utilizing available nitrogen. This efficiency is essential for minimizing nitrogen losses, which can negatively impact the environment. The work of Faver din *et al.* (2019) emphasizes the importance of effective nitrogen management to maximize animal performance while reducing environmental impacts. Additionally, studies like those of Binggeli (2022) highlight the importance of formulating rations that limit nitrogen emissions, which is particularly relevant in intensive farming systems.

5. Conclusion

This study highlights the importance of dietary choices on the health and productivity of sheep in Sahelian regions. The results show that the BSR and MHR rations, due to their high capacity to utilize dry matter and organic matter, allow animals to extract more essential nutrients. In particular, the MHR, with its high digestibility of nitrogenous matter, proves to be a valuable asset for promoting sheep growth, while the BSR appears to offer more effective protein utilization.

It is evident that forage quality plays a fundamental role in sheep nutrition. It influences not only their intake but also their overall health and productivity. By adapting our feeding practices and prioritizing high-quality forages like Maralfalfa, we can improve animal welfare while addressing challenges in raising livestock in arid environments.

Thus, it is essential to continue our efforts to explore and adjust our feeding methods. This will not only help optimize sheep productivity but also promote sustainable farming systems capable of facing climate change and increasing environmental pressures. Ultimately, investing in sheep nutrition is an investment in the future of livestock farming in Chad.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Agondangou, K. (2023). Étude de la rentabilité économique de la culture fourragère irriguée Maralfalfa (*Pennisetum Sp*.) au Tchad: enjeux et perspectives pour des systèmes d'élevage plus durables (Doctoral dissertation, Institut Agro Montpellier).

[2] Akpo, L. E., Banoin, M., and Grouzis, M. (2003). Effet de l'arbre sur la production et la qualite fourrageres de la vegetation herbacee: bilan pastoral en milieu sahelien. Revue de médecine vétérinaire, 154(10), 619-628.

[3] Assoumaya, C., Sauvant, D., and Archimède, H. (2007). Etude comparative de l'ingestion et de la digestion des fourrages tropicaux et tempérés. INRAE Productions Animales, 20(5), 383-392.

[4] Binggeli, S. (2022). Impacts économiques et environnementaux d'une mise à jour des recommandations en protéines et en acides aminés chez la vache laitière en contexte canadien et choix du modèle de formulation.

[5] Boulkhir, K. (2020). Impact de l'alimentation sur les performances de reproduction chez les ruminants (Bovins, Ovins, Caprins)«Synthèse bibliographique» (Doctoral dissertation, Université Mouloud Mammeri).

[6] Brouckaert, C. (2024). Valorisation des fourrages ligneux en élevage bovin.

[7] Cutullic, E., Delaby, L., Edouard, N., and Faverdin, P. (2013). Rôle de l'équilibre en azote dégradable et de l'alimentation protéique individualisée sur l'efficience d'utilisation de l'azote. Rencontres Recherches Ruminants, 20, 53-56.

[8] Dugué, M. J., Delille, H., and Malgrange, S. (2012). Caractérisation des stratégies d'adaptation au changement climatique en agriculture paysanne. Etude de capitalisation réalisée sur les terrains de coopération d'AVSF, 50.

[9] Faverdin, P., and van Milgen, J. J. (2019). Intégrer les changements d'échelle pour améliorer l'efficience des productions animales et réduire les rejets. INRA Productions Animales, 30(2), 305-322.

[10] Klein, H. D., Rippstein, G., Huguenin, J., Toutain, B., and Guerin, H. (2014). Les cultures fourragères (p. 264). éditions Quae.

[11] Kouakou N'G.D.V., Kouba M. et Thys E. 2016. Etude comparative de la digestibilité in vivo de l'herbe de guinée (Panicum maximum Jacq.) associée aux feuilles et tiges de patate douce (Ipomea batatas (L.) Lam) ou à l'herbe de lait (Euphorbia heterophylla L.) chez le lapin (Oryctolagus cuniculus L.) et le cobaye (Cavia porcellus L.). Tropicultura, 34 (2) : 158-165.

[12] Mian Oudanang, K. (2008). Dynamique des changements dans le secteur de l'élevage au Tchad: le cas de la filière lait de N'Djaména (Doctoral dissertation, AgroParisTech).

[13] Miégoué E.2016. Trois légumineuses fourragères(Arachis glabrata, Calliandra calothyrsus ou Desmodium intortum) comme source de protéines associées à deux graminées (Pennisetum purpureum et Panicum maximum) dans l'alimentation des cochons d'inde ((Cavia porcellus L.). Thèse de Doctorat (PhD) en Biotechnologie et Productions Animales. Université de Dschang. 158p.

[14] Mostefai, S. (2017). Estimation de la valeur nutritive des pâturages des prairies naturelles par la composition chimique dans la région de Yakouren dans la wilaya de Tizi-Ouzou (Doctoral dissertation, Université Mouloud Mammeri).

[15] Noumbissi M. N. B., Tendonkeng F, Zougou T G et Pamo T E 2014.Effet de différents niveaux de supplémentation de feuilles de Tithonia diversifolia (Hemsl) A Gray sur l'ingestion de la digestibilité in vivo de Pennisetum purpureum K. Schum. Chez le cobaye (Cavia porcellus L.). Tropicultura, 2014, 32, 3138-146.

[16] Oumar Mk, Miegoue E, Mouchili M, Fokom Wd, Azoutane J *et al.* (2023).Feed Intake and in Vivo Digestibility of Dominant Forage of Natural Pasture Supplemented with Acacia Albida Leaves in Arab Ewes. J Vet Sci Ani Husb 11(1): 104

[17] Richard, D., Alary, V., Corniaux, C., Duteurtre, G., and Lhoste, P. (2019). Dynamique des élevages pastoraux et agropastoraux en Afrique intertropicale (p. 268). éditions Quae.

[18] Tchoumboué J., Niba, A.T. et Kenfack, A. 2001. Comparative study on the influence of supplementation with two legumes (Arachis glabrata Benth. and Desmodium intortum) on the reproductive and growth performance of guinea pigs (Cavia porcellus L.). Bulletin of Animal. Health and Production. 49:74-83.