Nigerian J. Anim, Sci. 2025, 27 (2): 180 - 192

Short – Time Intake and Preference of Ratio of Gliricidia sepium: *Moringa oleifera* Leaf Meal by Yankasa Rams

Mohammed, A.A., Abdu, S.B., Hanwa, Y.A. and Abubakar, M.

Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State.
Corresponding Author: ewuzearaba@gmail.com; Phone number: 08032448376

Abstract

Nutritional evaluation using preference and short – time intake study as criteria for investigating ratio combinations of diets and performance in Yankasa rams. Five (5) Yankasa rams, aged 8-12 months with an average body weight of 14.69+0.02kg were used for the preference study, the study lasted 24 days. Animals were housed in pens, with concrete floors, de-wormed; given prophylactic treatment and access to clean water. The animals were offered 2000g of air-dried leaves of G. sepium and M. oleifera combinations in a cafeteria method of feeding. The animals were set free to make their choices within an hour (1hr) in a confined environment, the amount of feed consumed and refused were measured and recorded daily. The most and least preferred combinations were determined, using two indices: Relative preference index (RPI) and Coeffecient of preference (CoP). The short-time intake shows preference for 100GS:0MO combination. Yankasa rams showed higher intake (1363g/d) and preference (194.72) for the diet with combination (100GS:0MO).

Keywords: Yankasa rams, Preference, *Gliricidia sepium, Moringa oleifera*

Description of Problem

Most 'hooved' animals are considered ruminants amongst which includes Cattle, Sheep and goats. About 20% of the world's population is considered smallholders with livestock, and they have a great opportunity to improve income and raise their sustenance through the development of the livestock chain (1). Africa's total livestock population in 2018 was estimated at 2 billion poultry birds (1.9 billion chickens, 26 million guinea fowl, 27 million turkeys, 22 million ducks, and 11.5 million pigeons), 438 million goats, 384 million sheep, just under 356 million cattle, 40.5 million pigs, almost 31 million camels, and 38 million equines (including 30 million donkeys, 6.5 million horses, and 885,000 mules (2).

Sasu (3) reported that by 2050 in Nigeria, the estimated number of cattle, goats, sheep, and poultry in millions are 53.6, 207.8, 78.2, and 284.3 respectively, indicating a significant increase in livestock production, making sheep the third most populated species in the country after goats and cattle, and the estimated annual growth rate for the demand of livestock products is more than three percent. In Nigeria it has been estimated

that sheep and goats provide over 35% of the whole animal protein consumed (4).

Small ruminants are mainly kept under extensive systems of production including free ranging, semi – intensive, and pastoral system where they feed on natural pastures, crop residues, and shrubs (5).

Animal protein consumption in Nigeria and developing countries has been reported to be comparatively low (6). Protein – energy malnutrition (PEM) remains a major issue in Nigeria due to poverty and low animal source food (ASF) consumption (7). High costs of ASF like meat, fish, eggs and dairy make them unaffordable for low-income households, particularly in rural areas. In Nigeria, poverty affects over 70% of the population, limiting purchasing power for nutrient-dense foods. (8).

In developing countries, only 3% of dietary energy comes from ASF due to cost, compared to cereal-based diets. Low ASF supply in Nigeria stems from inadequate finance, high feed costs, diseases, and poor infrastructure (9). Household income positively impacts protein adequacy, while large family size reduces it (7). Current ASF intake in Nigeria is 15g/capita/day, far below the recommended 35g. Indigenous vegetables complement ASF, but food insecurity persists due to low dietary diversity and economic constraints (10). One of the ways of solving this problem (PEM) is by supplementary feeding (11), directing efforts at promoting and ensuring smallholder farmers have access to affordable, quality, quantity, improved animal feeds and welfare.

Sheep can tolerate higher percentage of *Gliricidia sepium and Moringa oleifera* leaf meal in their diet without complications arising from tannin and saponin toxicity. This will go a long way to alleviating inadequate feed supply in the dry season when problem of feeding becomes critical since *G. sepium* is available throughout the year. The importance of sheep in the livelihood of the rural Nigerian populace cannot be over emphasized.

The global demand for sustainable and cost-effective livestock feed solutions has intensified, particularly in tropical regions like Sub-Saharan Africa, where smallholder farmers face significant challenges. Sheep (Ovis aries), valued for their contributions to meat, milk, manure, and cultural practices, are a vital component of smallholder livestock systems due to their low initial investment, ease of management, and widespread acceptability (12). However, the scarcity of high-quality forages and the high cost of concentrate feeds during the dry season limit small ruminant production, driving the need for affordable, nutrient-rich alternatives (13).

Gliricidia sepium, a leguminous tree native to Central America and widely distributed across West Africa, the West Indies, and Southern Asia, emerges as a promising browse plant (12). Its leaves, containing 17–25% crude protein, offer high nutritional value and digestibility, making them a viable substitute for costly conventional feeds like soybean meal and cottonseed cake (12). Similarly, *Moringa oleifera*, another multipurpose tree, provides up to 25% crude protein, along with essential minerals like phosphorus and sodium, enhancing its suitability as a ruminant feed supplement (14). Both

species are drought-resistant, thrive in tropical climates, and produce substantial biomass, making them ideal for resource-constrained smallholder systems.

Despite their nutritional benefits, the presence of anti-nutritional factors, such as tannins and saponins, can affect palatability and intake, necessitating research into optimal feed combinations and preparation methods (shade drying, sun drying or wilting *G. sepium* leaves for 12–24 hours to enhance intake, as noted by (15). Previous studies have demonstrated the efficacy of browse plants like *G. sepium* in improving feed intake, digestibility, and weight gain in ruminants, including Bali cattle and West African Dwarf goat (16, 17). Moreover, *G. sepium's* condensed tannins have shown potential in controlling gastrointestinal parasites, offering an additional benefit for sustainable livestock management (18). Its insecticidal and antimicrobial properties further enhance its value as a multifunctional feed resource (19).

Given the rising costs of concentrate feeds and their inaccessibility to smallholder farmers (16), integrating locally available forages like *G. sepium* into ruminant diets is critical. Previous research has also highlighted the positive effects of leguminous leaf supplementation on intake, digestibility, and growth in sheep fed low-quality grasses (20). In view of the potential found in *G. sepium* and *M.oleifera*, it was considered interesting to determine the preference and short – time voluntary intake by Yankasa rams to be fed different combination ratio of *Gliricidia sepium:Moringa oleifera* leaf meal. This study aims to provide practical insights into optimizing *G. sepium*: *M. oleifere* use in smallholder systems, contributing to sustainable livestock production and resource conservation in tropical regions. The main objective of this study was to determine the short – time intake and preference of ratio of *Gliricidia sepium:M.oleifera* leaf meal by Yankasa rams.

Materials and Methods

Experimental site

The experiment was conducted at the Department of Animal Science Teaching and Research Farm. Ahmadu Bello University, Zaria. The farm is located at an elevation of 671m above sea level, latitude 11.10° North and longitude 07.38° East (21). The climate is characterised by a defined wet and dry season. Wet season starts from April to early May and ends in late September to early October while the dry season last from October to April. The total rainfall ranges from 748.6 - 1156.7mm with a long term average of 1058.6mm. Maximum air temperature of 37°C are recorded in May and minimum air temperature of 11.5°C recorded in December / January and relative humidity of approximately 70% during raining season. (22).

Sources of experimental materials

G. sepium leaves and twigs of between 0.5-0.8cm diameters were harvested at National Animal Production Research Institute Farm (NAPRI), Shika, and its environment at the beginning of rainy season from April and air dried at NAPRI Forage Production Unit open stall for three (3) days to 90% DM.

D. smutsii hay was obtained from National Animal Production Research Institute

(NAPRI), Forage Production Unit, Shika, Zaria, Kaduna State. Dried *Moringa oleifera* leaves was obtained from neighbouring villages in Zaria, Kaduna State and air dried.

Preference study

The cafeteria method was adopted in the preference study and was carried out on *G. sepium and M. oleifera combinations* to determine their level of intake and preference by Yankasa rams.

Animals and procedure

Five (5) Yankasa rams, aged 8-12 months with an average body weight of 14.69±0.02kg were used. Animals were housed in pens, with concrete floors, de-wormed; given prophylactic treatment and access to clean water. The animals were offered 2000g of air dried leaves of *G. sepium* and *M. oleifera* combinations in a cafeteria method of feeding. The animals were set free to make their choices within an hour (1hr) in a confined environment. The most and least preferred combinations were determined. The experiment lasted for twenty-four (24) days, consisting of fourteen (14) day adjustment and ten (10) day collection period.

Diets for the preference study

The diets for the preference study comprised of different combinations ratios of *G.sepium* and *M. oleifera* as follows:

1–100% *G. sepium* + 0% *M. oleifera,* DM basis

2–75% *G. sepium* + 25% *M. oleifera,* DM basis

3–50% *G. sepium* + 50% *M. oleifera,* DM basis

4–25% *G. sepium* + 75% *M. oleifera,* DM basis

Preference study procedure

The order of strategic placement of the test materials in the plastic feeding troughs was randomised daily to avoid the 'habit reflex' (23).

The preferred feed was assessed using two indices, relative preference index (RPI) and Coefficient of preference (CoP).

Intake of the leaves was recorded by deduction of remnants from the amount of feed offered and animals were allowed access to *Digitaria smutsii* for the rest of the day. Relative Preference index (RPI) was calculated per combination in air dried leaves forms by dividing proportion of each combination in the diet (its intake values) with that of the proportion of combination offered for each day and multiplied by 100 as described by (24). The relative preference index (RPI) values indicate the relative preference of each combination, with higher values indicating greater preference.

The coefficient of preference (CoP) was determined according to (24) as the ratio of the proportion of diet consumed divided by the proportion of diet offered on dry matter basis (DM). A fodder type was said to be preferred by animals to others when calculated CoP was greater than unity.

Chemical Analysis

The milled samples of (*G. sepium*, *M. oleifera* leaves; and *G. sepium*:*M.oleifera* mixture), samples were analysed for proximate using (25) procedures in triplicates on the samples, and the Acid Detergent Fibre (ADF) and Neutral Detergent Fibre (NDF) of feed samples were analysed according to the procedure

of (26). Anti – nutritional factors (tannins, saponins, phytates and oxalates) were quantified using standard procedures in the biochemical laboratory of department of Animal Science, Ahmadu Bello University, Zaria.

Data analysis

The data obtained were analysed using two indices, relative preference index (RPI) and Coefficient of preference (CoP)

Results and Discussion

Chemical composition of *Gliricidia sepium* (GS) and *Moringa oleifera* (MO) Leaves

The results in Table 1 shows the chemical composition of *Gliricidia sepium* (GS) and *Moringa oleifera* (MO leaves). Chemical composition significantly affects the palatability and intake of Yankasa rams. Dry matter content of *Gliricidia sepium* leaf meal (91.70%) was higher than the 67.03% and 79.44% reported by (27) and (28), respectively. The CP value of 17.26% obtained for *Gliricidia sepium* leaf meal was lower than the value (28.31%CP) reported by (27), but higher (15.30%CP) than value reported by (28). The crude protein content of *Gliricidia sepium* leaf is high, indicating a good source of protein. *Moringa oleifera* has higher crude protein (27.16% vs. 17.26%) while the crude fiber (8.17%CF) is lower than the value (17%CF) reported by (29).

Table 1: Chemical Composition of *G. sepium and Moringa oleifera* (%)

Parameters (%)	Test ingredients	
	Gliricidia sepium	*Moringa oleifera*
Dry Matter	91.70	90.99
Crude Protein	17.26	27.16
Ether Extract	2.96	1.77
Crude fibre	17.14	8.17
Ash	15.96	7.25
NDF	45.11	13.86
ADF	31.21	12.64
Hemicellulose	13.21	1.22
Lignin	11.04	1.07

NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre

Anti – nutritional factors in individual ingredients - *Gliricidia sepium* (GS) and *Moringa oleifera* (MO) leaves

Table 2 shows Anti – Nutritional Factors (ANFs) in individual ingredients. ANFs can bind nutrients, reduce digestibility, or cause toxicity, but levels in individual ingredients are relatively low for both plants - *Gliricidia sepium* (GS) and *Moringa oleifera* (MO) leaves. *Gliricidia sepium* contains phytate (1.71 mg/100g), oxalate (0.33 mg/100g), tannins (0.38 mg/100g), and saponin (2.00 mg/100g). *Moringa oleifera* has higher phytate (3.42 mg/100g) and tannins (0.42 mg/100g), but lower oxalate (0.26 mg/100g) and saponin (1.50 mg/100g). These concentrations are below thresholds that typically impair ruminant performance (e.g., tannins >5% DM can reduce protein utilization), (17)

and rumen microbes can degrade many ANFs. The low concentrations of the ANFs could be attributed to the method of processing (shade – dried) that *Gliricidia sepium* was subjected to before the commencement of the experiment. Drying *Acacia cyanophylla* foliage under shade or in the sun reduced the condensed tannin content, but sun drying was more efficient than drying in the shade (33). However, voluntary intake of dried *Acacia cyanophylla* foliage by growing or adult sheep did not differ from fresh Acacia foliage. Wilting Acacia foliage increased total DMI and DMI of Acacia foliage by goats compared to feeding fresh or dried Acacia foliages, but did not increase growth rate (17), they also reported in another study that cows fed wilted *Gliricidia sepium* up to 50% inclusion level had a better live weight gains, better feed utilization and/or efficiency. GS tannins in the study are less than 1% with saponins around 1-2%, while MO's phytate (3.42mg/100g) and tannins (0.42mg/100g) are higher but mitigated by processing like shade - drying. GS's higher saponins may confer antimicrobial benefits in the rumen but could affect palatability if bitter.

Table 2: Levels of Anti -nutritional factors in *Gliricidia sepium* and *Moringa oleifera* (mg/100g) leaf meal

Anti – nutrients (mg/100g)	*Gliricidia sepium* Dry sample	*Moringa oleifera* Dry sample
Phytate	1.71	3.42
Oxalate	0.33	0.26
Tannins	0.38	0.42
Saponin	2.00	1.50

Mg=Milligram, g=gram,

Reference values –
Tannins-2-3% (30), Saponins - < 2% (31), Phytate - 1.5-2% and oxalate – 0.04-1.50% (32)

Chemical composition of *G. sepium: M.oleifera* combinations and anti-nutritional factors (ANFs) in the combinations

Table 3 shows the chemical composition and Anti- nutritional factors in different ratio combinations of *Gliricidia sepium*:*Moringa oleifera* leaf meals. Mixing GS and MO at ratios of 100:0, 75:25, 50:50, and 25:75, shows progressive improvements in nutritive value as MO proportion increases. CP increases from 17.26% (100:0) to 21.81% (25:75), while CF decreases from 17.14% to 9.01%. Fiber fractions vary: NDF and ADF decrease overall (45.11% to 29.79% for NDF), but show fluctuations (ADF increases at 34.32% in 50:50). Hemicellulose and lignin decrease steadily (13.21% to 4.56% and 11.04% to 4.49%, respectively). ANFs also decrease: oxalate (0.33 to 0.25 mg/100g), tannins (0.38 to 0.23 mg/100g), phytate (1.71 to 1.14 mg/100g, with a decrease at 50:50), and saponin (2.00 to 0.90 mg/100g). This synergistic effect supports using combinations to balance protein and fiber

Table 3: Chemical Composition of *G. sepium, M.oleifera* Combinations (%)

Parameters	GS: MO 100: 0	GS: MO 75: 25	GS: MO 50: 50	GS: MO 25: 75
Dry Matter	91.70	91.25	90.38	90.17
Crude Protein	17.26	20.38	20.81	21.81
Crude fibre	17.14	14.27	11.92	9.01
ADF	31.21	28.82	34.32	25.23
NDF	45.11	40.09	40.06	29.79
Hemicellulose	13.21	11.27	5.74	4.56
Lignin	11.04	7.85	6.96	4.49
ANFs (Mg/100g)				
Oxalate	0.33	0.27	0.24	0.25
Tannin	0.38	0.32	0.21	0.23
Phytate	1.71	0.95	0.38	1.14
Saponin	2.00	1.60	1.40	0.90

ADF =Acid Detergent Fibre, NDF = Neutral Detergent Fibre, ANFs = Anti -nutritional Factors, GS = *Gliricidia sepium*, MO= *Moringa oleifera*.

Reference values –

Tannins-2-3% (30), Saponins - < 2% (31), Phytate- 1.5-2% and oxalate – 0.04-1.50% (32)

Short – time intake and preference of Yankasa Ram fed different ration of *G. sepium*:*M. oleifera* leaf meal.

Table 4 shows the difference in preference and acceptability by Yankasa rams in the dry matter intake. Multiple factors could explain these findings from both fodder and animal perspectives. The consumption of green fodders is influenced by plant species, presentation form, maturity stage, processing methods, and the chemical composition of the fodder (34). They also suggested that the presence of phytochemicals or other anti-nutritional factors may impact palatability and preference.

The result from this study shows that Yankasa rams prefer GS-heavy combinations, 100GS: 0MO, intake 1,363 g/d, CoP 1.94. The relative preference and acceptability by Yankasa rams were in the order of 100GS:0MO>50GS:50MO>75GS:25MO >25GS:75MO, the order of feed intake was similar to the relative preference, while the coefficient of preference are in the order of 100GS:0MO>50GS:50M0>75GS:25M0 >25GS:75MO. This could probably be due to the nutrive value of *Gliricidia* with Crude Protein content of its leaves at 17.14%. This agrees with the report of (35, 36) that legumes such as *gliricidia* and *Leucaena* (*Leucaena leucocephala* L) often have better nutritive value than shrub because only leaves comprise the allowed forage. In addendum, legume often have faster passage rate in the rumen due to lower fiber content, quick fermentation and particle disintegration (37). (38) also corroborated this study that sheep showed preference for fresh leaves because of the nutritive value of the plant especially tropical legumes like *gliricidia*. Other factors that influenced the choice of Yankasa rams in this study include sensory attributes—GS's higher fiber may provide bulk satisfaction, while MO's bitter

Table 4: Relative Preference Index (RPI) and Coefficient of Preference (CoP) of *G. sepium*, *M. oleifera* Combination offered to Yankasa rams

Parameters	GS:MO 100:0	GS:MO 75:25	GS:MO 50:50	GS:MO 25:75
Intake (g/d)	1363	578	945	379
RPI (%)	194.72	58.40	105.36	40.60
CoP	1.94	0.58	1.05	0.40

g = grame, GS = *Gliricidia sepium*, MO = *Moringa oleifera*, RPI= Relative Preference Index, CoP= Coefficient of Preference,
RPI= (Proportion of feed consumed/proportion of feed offered X 100), RPI >100% indicating preferred feed, RPI<100% indicating a less preferred feed, RPI=100% indicating no preference, with higher values indicating greater preference in the diet.
CoP= Ratio of the proportion of feed consumed to the proportion of feed offered,
If the coefficient of preference is:
. Greater than 1, the animals prefer the feed.
. Less than1, the animals avoid the feed
. Equal to 1, the animals have no preference

tannins or unfamiliar taste reduced appeal (39). This suggests sheep tolerate moderate fiber feeds and legume with better nutritive value.

Conclusion And Recommendations

Yankasa rams shows preference for high fibre - dense feed with the combination, 100GS:0MO, intake 1363g/d, RPI 194.72% and CoP of 1.94. In conclusion, *Gliricidia sepium* leaf meal can be a valuable protein source for sheep, its inclusion in diets should be carefully managed to mitigate the adverse effects of anti - nutritional factors on feed intake, growth performance, methane emission and economies of production.

From the results of this study, the following recommendations were made: *G. sepium* leaf meal can be used by livestock farmers as a good source of feed supplement during the peak of dry season to maintain live weight of ruminant animals. For sheep production it can be recommended in the diets of Yankasa rams to use 75-100% GS to maximize intake, with MO limited to 25-50% to avoid rejection. Planting of more *G.sepium* trees should be encouraged.

References

1. Lowder, S., Raney, T. and Skoet, J. (2023). The Global Distribution of Smallholder and Family Farms. CGAP (Consultative Group to Assist the Poor).
2. Nuvey, F.S., Mensah, Dorny, P.T., Houngbadi, A., Darteh, K.N., Narh, S., Quashie, Adu, F.B., Diop, M., Toure, O. And Unger, F. And Jost, C. (2020). Milk, and More: Policy innovation to shephered inclusive and sustainable livestock System in Africa. Malabo Montpellier Panel Report.
3. Sasu, D.D. (2022). The current and projected livestock population in Nigeria from 2012 – 2050. https://www.statista.com/statistics/1131581/current-and projected-livestock-population-in-nigeria/.

4. Shamaki, D., Olaleye, O.D., Obi, T.U., Diallo, A., Majiyagbe, K.A., Lombin, L.H.and Barrett, T. (2004). Peste De Petits Ruminants (PPR) in Nigeria: Serological and Molecular Epidemiology. Vom. *Journal of Veterinary Science*, 1:18-27.
5. Adams, F. and Ohene – Yankyera, K.(2016). Looking beyond the market: Extimating the Economic Benefits of Managing Small Ruminants in two Agro – Ecological Zones of Ghana. In: *Proceedings of Conference on Inclusive Growth and Poverty Reduction in the IGAD Region*; IGAD: Djibouti City, Djibouti, p 127, C.A.
6. de Vries-Ten Have, J., Owolabi, A., Steijns, J., Kudla, U. and Melse-Boonstra, A. (2020). Protein intake adequacy among Nigerian infants, children, adolescents and women and protein quality of commonly consumed foods. *Nutrition Research Reviews*, 33(1): 102–120. doi:10.1017/S0954422419000222.
7. Abdulraheem, M. A., Muhammad-Lawal, A., Olasore, A. A. and Oni, O. O. (2016). Assessment of animal protein consumption and food security among rural households in Kwara State, Nigeria. *African Journal of General Agriculture*, 12(1):1–12.
8. Schulte-Herbrüggen, B., Cowlishaw, G., Homewood, K.and Rowcliffe, J. M. (2017). Rural protein insufficiency in a wildlife-depleted West African farm-forest landscape. *PLoS ONE*, 12(12): e0188109. doi:10.1371/*journal.pone*.0188109.
9. Bamaiyi, P. H. (2024). Factors militating against animal production in Nigeria. *International Journal of Livestock Research*, 14(10):1–10.
10. Omonona, B. T. and Agoi, G. A. (2019). Food security implications of protein demand of underutilised indigenous vegetables farming households in Southwestern Nigeria. *Journal of Food Security*, 7(5): 183–191. doi:10.12691/jfs-7-5-5.
11. Ubesie, A. C. and Ibeziako, N. S. (2012). High burden of protein-energy malnutrition in Nigeria: Beyond the health care setting. *Annals of Medical and Health Sciences Research*, 2(1):66–69. doi:10.4103/2141-9248.96941.
12. Alamu, E. O., Adesokan, M., Fawole, S., Dixon, D.M. and Mehreteab, T. (2023).*Gliricidia sepium* (Jacq.) walp applications for enhancing soil fertility and crop nutritional qualities: a review. *Forests*, 14, (3):635.
13. Alan, J.L., Gavin, D.K., Robert, G.D., Gavin, J.P. and Hayley, C.N. (2013). The potential of a salt-tolerant plant (*Distichlis spicata* cv. NyPa Forage) to treat effluent from inland saline aquqculture and provide livestock feed on salt-affected farmland. *Science of the total Environment*, 445-446:192-

201.

14. Aye, P.A and Adegun, M. K. (2013). Chemical Composition and some functional properties of *Moringa*, *Leucaena* and *Gliricidia* leaf meals. *Agriculture Biological Journal of North America,* 4 (1): 71-77.

15. Feyisa, B., Feyissa, T. and Melesse, A. (2021). Palatability and intake of browse species in tropical ruminants. *Journal of Animal Science and Technology,* 62(3): 419–426.

16. Muhammed, R., Syanhdar, B., Sjamsuddin, G. and Ihan, S. (2019). Effect of Supplementation with *Gliricidia sepium* leaves on performance of Bali cattle fed elephant grass. Faculty of Animal Sciencee, Hasanuddin University, Makassar, Indonesia.

17. Molina-Botero, I. C., Arroyave-Jaramillo, J. and Valencia-Salazar, S. (2019). Effects of tannins and saponins contained in foliage of *Gliricidia sepium* and pods of *Enterolobium cyclocarpum* on fermentation, methane emissions, and rumen microbial population in crossbred heifers. *Animal Feed Science and Technology, 251*: 1-12.

18. Hoste, H., Meza-OCampos, G., Marchand, S., Sotiraki, S., Sarasti, K., Blomstrand, B. M., Williams, A. R., Thamsborg, S. M., Athanasiadou, S., Enemark, H. L., Torres Acosta, J. F., Mancilla-Montelongo, G., Castro, C. S., Costa-Junior, L. M., Louvandini, H., Sousa, D. M., Salminen, J.-P., Karonen, M., Engstrom, M., Charlier, J., Niderkorn, V. and Morgan, E. R. (2022). Use of agro-industrial by-products containing tannins for the integrated control of gastrointestinal nematodes in ruminants. *Parasite*, 29 (10):1-16.

19. Cherian, T. and Thambi, M. (2019). Phytochemical investigation of the leaves of *Gliricidia sepium* and its antimicrobial properties. *Pharma Innovation*, 8(2):594-596.

20. Yusuf, A., Shehu, B and Murtala, U. (2023). Role of browse Tree Legumes as a Dietary Supplements for Ruminants: A Review. *Nigerian Journal of Animal Science*, 6(2): 144 -155.

21. Ovismaps, (2023). Ovi location map: Ovi Earth Imagery Data.

22. IAR, (2023). Institute for Agricultural Research, Ahmadu Bello University, Zaria. Meteorological Data Information of Samaru and its environments.

23. Kaitho, R.J., Umunna, N.N., Nsahlai, I.V., Tamminga, S., Van, Bruchem, J. and Vandwouw, M. (1996). Palatability of multipurpose tree species: effect of species and length of study on intake and relative palatability by sheep. *Agroforestry Systems*, 33:249-261.

24. Ziblim, A. I., Oppong, S. K., Danquah, E.and Collins, A. N. (2019). Feed intake and animal preference rating of indigenous forage shrub species in the Savanna ecosystem of Ghana. *Livestock Research for Rural*

Development, 31(7).

25. AOAC, (2019). International, Association of Official Analytical Chemists, Official Methods of Analysis. 21th edition. Association of Official Analytical Chemists, Washington DC, USA) AOAC Press Pp 200 – 210.
26. Van Soest, P.J. and Robertson, J.B. and Lewis, B.A. (1991). Methods for dietary fibre, NDF and Starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74:3583 -3592.
27. Okoruwa , I., Apata, B.O. and Babayemi, O.J. (2017). "Nutrient digestibility and blood metabolites of growing sheep as influenced by dietary supplementation with *Gliricidia sepium* and neem leaves meal." *International journal of Agricultural Economics and Biosciences* (ILAEB), 2(2):78 – 85.
28. Akinfemi, A., Adebayo, B.J. and Ogunbosoye, D.O. (2020). Nutritional improvement of rice straw treated with urea-molasses and its effect on in vitro digestibility. *Journal of Agricultural Science and Practice*. 5(1): 74-79.
29. Okafor, E.C. (2017). Performance of Red Sokoto Goats fed Inclusion Level of Mixed *Gmelina* (*Gmelina aborea*) and *Moringa* (*Moringa oleifera*) Leaf meal in *Digitaria smutsii* Hay based diets. Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria. Ph.D Dissertation, November, 2017. Pp 56-147.
30. Orzuna-Orzuna, J.F., Dorantes – Iturbide, G., lara-Bueno, A., Mendoza – Martinez, G.D., Miranda-Romero, L.A. and Hernandez-Garcia P.A. (2021). Effects of Dietary Tannins' Supplementation on Growth Performance, Rumen Fermentation, and Enteric Methane Emissions in Beef Cattle: A Meta – Analysis." *Journal of Sustainability*, 13(13): 7410.
31. Yanza, Y. R., Irawan, A., Jayanegara, A., Ramadhani, F., Respati, A. N., Fitri, A., Hidayat, C., Niderkorn, V., Cieslak, A. and Szumacher-Strabel, M.. (2024).
32. Samtiya, M., Aluko, R.E. and Dhewa, T. (2020). Plant Food Anti – Nutritional Factors and Their Reduction. *Journal of Food Production, Processing and Nutrition*. 2: 1-14.
33. Thamkaew, G., Sjöholm, I. and Galindo, F. G. (2020). A review of drying methods for improving the quality of dried herbs. Critical Reviews in *Food Science and Nutrition*, 61(8):1763-1786.
34. Kalio, G.A., Oji, U.I. and Larbi, A. (2006). Preference and acceptability of indigenous and exotic acid soil – tolerant multipurpose trees and shrubs by West African Dwarf sheep. *Agroforestry Systems*, 67: 123 - 128.
35. Lee, M. A. A. (2018). Global comparison of the nutritive values

of forage plants grown in contrasting environments. *Journal of Plant Research*, 131:641-654.

36. Rusdy, M., Yusuf, M. and Ismartoyo (2020). Utilization of *Leucaena leucocephala* and *Gliricidia sepium* as supplements by goats fed *Panicum maximum* basal diet. *Tropical Animal Health and Production*, 52: 541-545.
37. Martin, C, Copani, G. and Niderkorn, V. (2016). Impacts of forage legumes on intake, digestion and methane emissions in ruminants. *Legume Perspectives* 12: 24-25.
38. Ban, C. B., Paengkoum, P., Paengkoum, S. and Purba, R.A.P. (2022). Feeding meat goats mangosteen (*Garcinia mangostana* L.) peel rich in condensed tannins, flavonoids, and cinnamic acid improves growth performance and plasma antioxidant activity under tropical conditions. *Journal of Applied Animal Research*, 50 (1): 307-315.
39. Gninkplekpo, E.L.R., Koura, B.T., Lesse, P.D.A., Yaoitcha, A., Accalogoun, J., Hornick, J.L., Cabaraux, J.F and Houinato, M.R.B. (2024). Forage Preference, Voluntary intake and in vivo Digestibility of Six tropical tree leaves by sheep in semi – Arid Areas in Benin Republic (West Africa). *Sustainablity*, 16 (6): 270. https://doi.org/10.3390/su16062270.