S. Afr. J. Agric. Ext. Kujoana, Mugwabana, Tyasi & Chitura
Vol. 51 No. 1, 2023: 100-124
10.17159/2413-3221/2023/v51n1a13466

Knowledge Validation and Nutritional Qualities of Fodder Trees Browsed by Goats in the Gumela Rural Area in Limpopo Province, South Africa

Kujoana, T.C.[1], Mugwabana, J.T.[2], Tyasi, T.L[3]. and Chitura, T.[4]

Corresponding Author: T.C. Kujoana. Correspondence Email: tlou.kujoana@gmail.com

ABSTRACT

In sub-Saharan Africa, goat farming has shown to be a significant intervention in the fight against poverty. However, the productivity of goats is threatened by several challenges, such as limited forage availability, especially during dry seasons when the quantity and quality decline. The study aimed to gather smallholder farmers' knowledge on the identity and nutritional qualities of fodder trees browsed by goats in the study area. Fourteen smallholder goat farmers were interviewed using a semi-structured questionnaire. Botanical identification and nutritional analysis of mentioned browse plants were conducted at the Animal Production Laboratory, University of Limpopo, South Africa. Capparis tomentose, Euclea crispa and Cassine transvaalensis had higher ($p<0.05$) dry matter content. Ziziphus mucronata had higher ($p<0.05$) ash content. Maerua angolensis had higher ($p<0.05$) crude protein content, while Colophospermum mopane had a higher ($p<0.05$) energy content. Colophospermum mopane was ranked the most browsed plant (43%), whereas Ziziphus mucronata and Maerua angolensis were ranked the least browsed plants. Colophospermum mopane and Sclerocarya birrea were classified as bad sources of goat feed. Most of the identified feed materials had crude protein and energy levels higher than the recommended minimum required levels for the maintenance of essential functions of goats.

[1] MSc Student, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: tlou.kujoana@gmail.com, Orcid 0000-0002-7078-2736

[2] Senior Lecturer, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: joseph.mugwabana@ul.ac.za

[3] Associate Professor, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: louis.tyasi@ul.ac.za, Orcid 0000-0002-3519-7806

[4] Lecturer, University of Limpopo, Department of Agricultural Economics and Animal Production, Email: teedzai.chitura@ul.ac.za, Orcid 0000-0001-9676-7166

Findings from this study indicate that farmers had some knowledge of the feed materials available for goat feeding, even though most farmers in the study area did not know how to determine the nutritional qualities of the available feed materials. The knowledge gathered from this study contributes to the body of literature on the use of indigenous feed resources to improve goat production, which has the potential to alleviate poverty and reduce unemployment in line with the National Development Plan 2030 of the South African government.

Keywords*:* Browsed plants, Crude protein**,** Capparis tomentose, Colophospermum mopane, Smallholder goat farmers

1. INTRODUCTION

Goat rearing has proved to be an important intervention to alleviate poverty in sub-Saharan Africa. In South Africa, 50% of the indigenous goat population is in the hands of small-scale farmers (Ng'ambi *et al*., 2013). Goats are known to adapt to various agroecological zones, and their hardiness presents an opportunity to increase their population, especially among smallholder farmers (Rout & Behera, 2021). Milk from goats is highly-priced because of its quality. It can also be used as a replacement for human milk in immune-compromised patients since it is rich in proteins compared to milk from cows (Department of Agriculture, Fisheries and Forestry [DAFF], 2019). However, optimal productivity in all classes of animals, including goats, can only be realised when the nutritional qualities of feeds are improved. The main challenge to improved goat production performance in rural areas of South Africa is limited forage availability (Brown *et al.,* 2016). This challenge is more pronounced during the drought and dry winter periods, often leaving goats to feed on fodder materials low in energy and proteins, reducing their production performance (Luthuli, 2018). In addition, smallholder goat farmers often lack the modern management skills necessary for improved goat production and resort to low-input farming.

The farmers depend mainly on indigenous knowledge of the feed types that are mostly preferred and consumed by their animals. However, knowledge of the feed and animal factors that may influence the choice of feed as well as the nutritional qualities of the feeds is often lacking (Hundal *et al*., 2016). Ramukhithi *et al*. (2018) identified low productivity in rural goat farming as a threat to sustainability. There is considerable scope for raising rural income and food security through improvements in goat production. Feed conservation during the rainy season could address challenges associated with feed shortage during the drought and dry periods. Improved goat production can help reduce poverty and the unemployment rate; these are in line with the National Development Plan 2030 of the South African government (NDP, 2012). Therefore, this study tried to solicit rural goat farmers' knowledge on the utilisation and nutritional qualities of fooder trees in the study area.

2. LITERATURE REVIEW

Communal goat production relies mainly on natural pastures, as indigenous goats normally receive fewer or no supplements, even during the dry seasons (Mbiriri *et al*., 2012). The farmers utilise indigenous fodder tree knowledge to optimise goat production during the dry seasons. Since fodder trees are readily available in these regions, there is great potential for improved goat productivity. Nonetheless, there is limited reference to scientific data due to various constraints, such as a lack of resources and information. Habermann *et al*. (2019) observed that even though forage quality and availability are often high during the rainy seasons, palatability is soon lost because of the rapid growth associated with the high temperatures in tropical regions. Gebremedhin *et al.* (2020) and Das *et al*. (2021) indicated that the quality of forages and grasses in tropical areas could fall below 8% crude protein during dry seasons. Deterioration in feed quantity and quality during the dry seasons severely affects goat productivity in those areas, even though most indigenous goat breeds can survive these harsh conditions, partly due to their ability to utilise various plant species as feed (Nair *et al*., 2021). Mehmood *et al.* (2020) recommended harvesting forage during this time of excess production for use during periods of feed scarcity. Other recommended measures include using stored feed materials such as silage, hay, postponed pastures and feeding leguminous tree pods as nutritional feed supplements (Garcia-Torres *et al.*, 2003). William (2015) recommended using *Acacia karroo* species (leaves and seed pods) for goat feeding, especially in the communal areas where this plant species is in abundance.

S. Afr. J. Agric. Ext. Kujoana, Mugwabana, Tyasi & Chitura
Vol. 51 No. 1, 2023: 100-124
10.17159/2413-3221/2023/v51n1a13466 (License: CC BY 4.0)

3. METHODOLOGY

3.1. Study Site

The study was conducted in the Gumela indigenous goat farming area, which smallholder farmers dominate. Gumela lies in the Southern African Lowveld vegetation system in the Thulamela Local Municipal area of the Vhembe District, Limpopo province, South Africa (Figure 1). The Venda ethnic group dominates the Thulamela Local Municipal area. The municipality is classified as a sub-tropical type of climate, with most rain falling from October to March in the summer months. Climatic conditions in Thulamela Local Municipality are suitable for the growth of perennial plants (Nell & Van der Walt, 2017). The unique topographical position of the area, its diverse plant communities, the Vhembe Biosphere Reserve, which falls within this municipality, the grasslands with scattered trees, short open woodland and bushes of different kinds that cover the entire municipality made Thulamela Local Municipality a good area for our study.

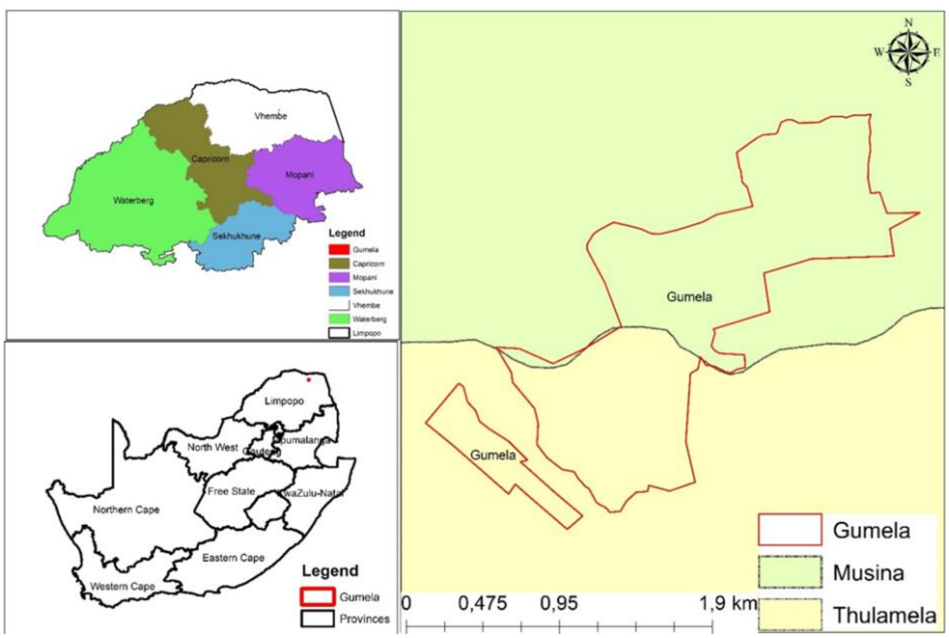

FIGURE 1: The Geographical Map Indicating the Location of Thulamela and Musina Local Municipalities with the Gumela Area Highlighted (Source: Municipal Demarcation Board, 2015).

3.2. Sampling Process

The researchers used the purposive sampling method to select indigenous goat farmers who participated in the study. Fourteen goat farmers who owned a minimum of 50 goats under an extensive management system were selected based on the list of goat farmers in the study area as provided by the local office of the Limpopo Department of Agriculture and Rural Development (LDARD). The selected farmers were all males within the 60 – 70 years age group.

3.3. Data Collection

Ethical clearance for this study was obtained from the University of Limpopo Turfloop Research and Ethics Committee (PN: TREC/298/2020: PG). The researchers developed a semi-structured questionnaire to guide the discussions during data collection, carried out from July to September 2020. Questions were designed in the local vernacular language (Tshivenda) for better understanding by the selected farmers. Focus group discussions and field-based cross-sectional surveys followed by personal interviews. These were critical to harmonise the findings gathered from individual interviews and facilitate information sharing. During the field walks, goats were followed to find and collect samples of plants browsed and reported during the interviews. Results from individual participants were related to more general data emerging from the focus group discussions. Following the collection of browsed feed materials from the field, each respondent was further asked to judge each feed material as either good or bad, comment on their nutritional qualities, and give reasons behind the outcome of their judgment. Issues related to the knowledge of trees and shrubs and information on availability and acceptability by the animals were discussed during the interviews. Photographs of the plant samples collected were taken to facilitate their identification. Collected plant samples were placed in brown envelopes and taken to the Department of Biodiversity at the University of Limpopo for botanical identification. Samples were dried in the Animal Production Laboratory at the University of Limpopo, then grounded to a fine powder using an electric grinder (Model: FZ-102) with a mesh size of 0.5 mm and stored in well-labelled airtight polythene bags for chemical analysis.

3.4. Chemical Analysis

The collected samples from feed materials were taken to the Animal Production Laboratory at the University of Limpopo for dry matter, ash, energy and crude protein analysis. DM determination (AOAC., 2005): the dry matter of the collected samples from the identified browsed fodder plant species was determined according to the AOAC (2005). Thoroughly cleaned crucibles were placed in the oven at 105°C for 30 minutes, then transferred to a desiccator and cooled to room temperature (25 ºC). The crucibles were then weighed. Samples were weighed, placed into crucibles, and placed in the oven overnight at 105 ºC. The crucibles and contents were weighed as soon as possible to prevent moisture absorption. Dry matter was calculated as follows:

DM (%) = Weight of the sample before drying/Weight of the sample after drying x 100

Determination of ash (AOAC., 2005): Air-dried browsed plant samples (2 g) were weighed and placed in pre-weighed clean-labelled crucibles. The sample plus the crucible were placed in the muffle furnace at 550 ºC overnight. The crucible and content were weighed as soon as possible to prevent moisture absorption. Ash determination was calculated as follows:

Ash weight = (Weight of beaker + ash) - (Weight of beaker)

Ash (%, DM basis) = (AWt/Dry sample weight) x 100

Determination of nitrogen content (AOAC., 2005): Nitrogen contents of the browsed plant samples were determined using the Kjeldahl procedure (AOAC., 2005). The formula for the calculation of the nitrogen content of the samples was as follows:

N (%) = (ml acid titrated - ml blank titrated) x (Acid N x 0.014 x 100)/Weight of sample in grams (g).

Determination of energy content (AOAC., 2010): the energy content of the browsed plant samples was determined using The Bomb Calorimeter (AOAC., 2010). The formula for the determination of the energy content was as follows:

Energy (joules) = Mass of water (g) × 4.2 (J/g ºC) × Temperature increase (ºC)

3.5. Statistical Analysis

Data collected using semi-structured questionnaires were fully transcribed, translated into English, and entered in Microsoft excel. Data was further transferred to International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS), version 25 (IBM SPSS Statistics, 2017) for analyses of rankings, categorisation, reasons for the judgment and quality assessment criteria by the respondents. Furthermore, the data on the chemical composition (DM, ash, CP, and energy contents) of the collected samples on the identified fodder trees browsed by goats at the Gumela indigenous goat farming area was subjected to General Linear Model (GLM) procedures using the Statistical Analysis of Software (SAS, 2010). Treatment means were compared using the Tukey test for multiple comparisons at the 5% probability level. The following model was used:

$$Y_{ij} = \mu + T_i + e_{ij}$$

whereby:

Y_{ij} = The nutrients (Dry matter, Ash, Energy, and Protein content)

μ = Overall mean,

T_i = Effect of feed materials (tree leaves and grass) and

e_{ij} = Residual error.

4. RESULTS AND DISCUSSION

4.1. Plant Species Browsed by Goats in the Study Area

As reported in Table 1, 15 fodder trees were reported to be available and browsed by goats at the Gumela indigenous goat farming area of Vhembe district in Limpopo province and were further identified by the respondents in their local Tshivenda names. Furthermore, the identification of the browsed fodder plants through their botanical names was carried out at the botanical laboratory of the Department of Biodiversity, University of Limpopo. Goats utilised either leaves, fruits, pods, and seeds of the following fodder trees; *Dichrostachys cinerea* (Murenzhe), *Boscia albitrunca* (Muthobi), *Ziziphus mucronata* (Mutshetshete) and *Maerua angolensis* (Mutambanamme) while the rest of the fodder plant species had their leaves as the browsed parts.

The current study results show that all the respondents in the Gumela indigenous goat farming area had some knowledge of fodder trees utilised by their goats. Based on the current findings, leaves were the most used parts of the plants, followed by fruits and pods/seeds. These results align with the findings of Mutie *et al*. (2020), who reported that goats mostly consume flowers, fruits, stems and leaves. Moreover, goats can select different plant parts and species from those they encounter (Mellado, 2016; Berman *et al.,* 2017).

TABLE 1: Plant Species Browsed by Goats, Their Habitats and Favoured Plant Parts at Gumela Communal Goat Farming Area

Local names (Tshivenda)	Botanical name	Habitat	Plant parts utilised
Mupani	*Colophospermum mopane*	Tree	Leaves
Muvhuyu	*Adansonia digitata*	Tree	Leaves
Mufula	*Sclerocarya birrea*	Tree	Leaves
Muṱwari	*Terminalia prunioides*	Tree	Leaves
Musingizi	*Combretum apiculatum*	Tree	Leaves
Munanga	*Senegalia galpinii*	Tree	Leaves
Gwambazi	*Capparis tomentos*	Tree	Leaves
Mutangule-Ngele	*Euclea crispa*	Tree	Leaves
Musu	*Vachellia tortilis*	Tree	Leaves
Murenzhe	*Dichrostachys cinerea*	Tree	Leaves and Pods
Muthobi	*Boscia albitrunca*	Tree	Leaves and Fruits
Mutshetshete	*Ziziphus mucronata*	Tree	Leaves and Fruits
Muembe	*Annona senegalensis*	Tree	Leaves
Mutambanamme	*Maerua angolensis*	Tree	Leaves and seeds
Mulumanamana	*Cassine transvaalensis*	Tree	Leaves

Nutritional Composition of Browsed Fodder Plant Species

Data presented in Table 2 shows that *Capparis tomentos* (Gwambazi), *Euclea crispa* (Mutangule-Ngele), and *Cassine transvaalensis* (Mulumanamana) browsed plant species had higher ($p<0.05$) dry matter (DM) content .*Ziziphus mucronata* (Mutshetshete) had higher ($p<0.05$) ash content.*Maerua angolensis* (Mutambanamme) had higher ($p<0.05$) crude protein (CP) content, while *Colophospermum mopane* (Mupani) had higher ($p<0.05$) energy content.

According to the information the farmers revealed during the data collection process, Gumela communal goat farming area experienced excessive drought before the data collection period. Brown *et al*. (2016) indicated that due to erratic rainfall patterns, the quality and quantity of available fodder declines and goats utilise feedstuffs from low-quality natural pastures which are low in proteins. However, some smallholder goat farmers in the study area provided minimal supplemental feeds in the form of pellets. Other smallholder goat farmers cut tree branches to increase feed accessibility, especially during the dry winter when the veld is dry. Couch et al. (2021) also noted and recommended such practices. During the interviews, the respondents indicated that most livestock mortalities are experienced during dry periods, although the exact cause for this could not be ascertained. One of the possible explanations for the high mortalities during the dry periods is the lack of availability of fodder plants which leads to animals consuming poisonous plants.

Luginbuhl (2020) reported that poisonous plants are primarily consumed when animals are faced with situations of acute feed shortage. The nutritional value of fodder plants depends on factors such as the plant species, plant part, maturity stage, and climate. Ibrahim and Usman (2021) reported that, unlike other grass or plant species that dry off and lose their nutritional value during dry seasons, most browse species can maintain their greenness and nutritional value throughout the year. However, the nutritional value of browsed fodder plants depends on factors such as moisture content, intake and digestibility (Hart *et al*., 2022). Determining the DM content would be important since optimal DM intake improves rumen microbial populations (Kinley, 2020). Yousfi (2016) stated that, on average, goats consume 3-4% of their body weights (BWs). Other factors such as palatability of the available feed and physiological statuses such as growth phase, pregnancy and lactation state were also reported to affect DM intake even though it is often the concentration of crude protein in the feedstuffs that has the most impact on the performance of animals (Yusuf, 2020).

The ash content indicates the degree of mineral deposit in plant materials (Hihoto *et al*., 2022). Therefore, the nutritional composition of browsed fodder plant species in the Gumela indigenous goat farming area was lab-analysed. The study's findings revealed that *Annona senegalensis* had the highest ash content (16%) and *Capparis tomentose, Euclea crispa*, and *Cassine transvaalensis* had high DM contents of above 90%. Ash values for the browse species reported in the present study are higher than those reported by Habte *et al*. (2012), which could be due to variations in the soil types from where the samples were collected. As a result, it is critical to investigate further the DM and mineral contents of the browsed species in the study area since no scientific study has been conducted on the DM and ash contents of those plant species identified at the Gumela communal goat farming area. Browse species analysed in this study had lower crude protein (CP) levels than those reported by Habte *et al.* (2021); however, they were comparable to those reported by Rivera- Méndez *et al*. (2017) and Dalle (2020). Kasale (2013) mentioned that proteins are the most significant nutrients in livestock feeding for optimal feed intake and microbial functions. However, in ruminant nutrition, nitrogen and its different compounds are of greater relevance than proteins and amino acids. The CP content of the barks of *Maerua angolensis* reported in the present study is similar to the findings of Williams *et al.* (2019) and higher than the recommended minimum levels of 8% crude protein for optimal ruminal microbial functioning and hence optimal feed intake (Brown *et al*., 2018). However, Mamer (2017) reported lower CP levels for the leaves of *Maerua angolensis*. Considering its high CP levels, barks of *Maerua angolensis* are recommended for inclusion as supplements to meet the animal body's daily protein requirements.

Moreover, all the browsed species reported in our study had CP contents higher than the recommended minimum levels (Fan *et al*., 2017) except for *Annona senegalensis* leaves, similar to the findings of Fayum *et al*. (2018). However, Mathew *et al.* (2018), Leite *et al.* (2020), and Al Kazman *et al.* (2022) reported higher CP levels for the leaves and seeds of *Annona senegalensis* of 9% and 17%, respectively. The results revealed that *Colophospermum mopane* leaves had higher energy content than the other browse plants reported in the present study. The energy levels are acceptable for goat feeding (Kabir *et al.*, 2022). The importance of energy in animal health cannot be overemphasised since energy is considered essential in the diets of browsers (Jiwuba *et al*., 2021). However, Makhado *et al*. (2016) and Jiwuba *et al.* (2021) reported lower values of 19 MJ/kg and 11 MJ/kg for *Colophospermum mopane* leaves.

TABLE 2: Nutritional Composition (% DM) of the Identified Browsed Plant Materials from Gumela Indigenous Goat Farming Area

Plant species	DM	Ash	CP	Energy
Colophospermum mopani (Mupani)	$93.74^{abc}\pm0.19$	$3.96^{ij}\pm0.32$	$16.33^{c}\pm0.43$	$22.67^{a}\pm0.12$
Adansonia digitata (Muvhuyu)	$89.27^{e}\pm0.12$	$8.36^{cde}\pm0.22$	$14.60^{d}\pm0.12$	$11.67^{g}\pm0.09$
Sclerocarya birrea (Mufula)	$85.67^{f}\pm0.14$	$5.43^{ghi}\pm0.58$	$10.33^{e}\pm0.15$	$17.10^{d}\pm0.17$
Terminalia pruniodas (Mutwari)	$93.61^{abc}\pm0.44$	$7.76^{cdef}\pm0.28$	$8.50^{f}\pm0.17$	$16.73^{d}\pm0.15$
Combretum hereroense (Musingidzi)	$91.18^{cde}\pm1.75$	$5.23^{hi}\pm0.21$	$10.70^{e}\pm0.06$	$17.97^{bc}\pm0.23$
Acacia galpinii (Munanga)	$93.29^{abcd}\pm0.04$	$2.67^{j}\pm0.32$	$14.97^{d}\pm0.02$	$16.84^{d}\pm0.18$
Capparis tomentosa (Gwambazi)	$95.33^{a}\pm0.33$	$7.31^{defg}\pm1.11$	$18.90^{b}\pm0.17$	$12.67^{f}\pm0.09$
Euclea crispa (Mutangule-Ngele)	$94.83^{a}\pm0.17$	$6.02^{fgh}\pm0.21$	$18.83^{b}\pm0.15$	$6.83^{j}\pm0.18$
Acacia tortilis (Musu pods)	$93.20^{abcd}\pm0.76$	$3.13^{j}\pm0.32$	$14.93^{d}\pm0.26$	$18.73^{b}\pm0.12$
Dichrostachys cinerea (Murenzhe)	$94.20^{ab}\pm0.10$	$2.22^{j}\pm0.24$	$14.93^{d}\pm0.13$	$9.9^{h}\pm0.21$
Boscia albitranca (Muthobi)	$90.77^{de}\pm0.21$	$9.67^{c}\pm0.16$	$19.19^{b}\pm0.20$	$12.24^{fg}\pm0.18$
Ziziphus mucronata (Mutshetshete)	$93.83^{abc}\pm0.17$	$8.93^{cd}\pm0.19$	$18.63^{b}\pm0.15$	$15.20^{e}\pm0.21$
Annona senegalensis (Muembe)	$91.56^{bcde}\pm0.26$	$15.99^{a}\pm0.35$	$2.96^{g}\pm0.17$	$17.27^{cd}\pm0.20$
Maerua angolensis (Mutambanamme)	$89.86^{e}\pm0.26$	$13.98^{b}\pm0.13$	$21.81^{a}\pm0.11$	$16.97^{d}\pm0.23$
Cassine transvaalensis (Mulumanamana)	$94.80^{a}\pm0.12$	$9.13^{c}\pm0.12$	$17.27^{c}\pm0.19$	$9.00^{j}\pm0.21$

a, b, c, d = mean values along the same column with different superscripts are significantly different ($p<0.05$)

4.2. Ranking, Categorisation, Judgment and Quality Assessment Criteria of the Browsed Plant Species by the Respondents

The identified fodder trees at the Gumela communal goat farming area were ranked according to their utilisation (Table 3). *Colophospermum mopane* (Mupani) was highly ranked by 43% of the respondents as the most browsed plant species, while only % of the respondents ranked *Ziziphus mucronata* (Mutshetshete) and *Maerua angolensis* (Mutambanamme) as the least browsed fodder trees. The field walks undertaken by the researchers also revealed the same plants mentioned by the respondents as the preferred ones during browsing. The results showed that only two fodder plants, namely: *Colophospermum mopane* (Mupani) and *Adansonia digitata* (Muvhuyu), were classified as bad by 14 and 21% of the respondents, respectively, while the rest were classified as being good for goat feeding (Table 4). *Sclerocarya birrea* (Mufula) (86%) and *Terminalia prunioides* (Mutwari) (71%) were classified highly as good fodder plants, and the least mentioned fodder plants were *Senegalia galpinii* (Munanga) (21%), *Dichrostachys cinerea* (Murenzhe) and *Vachellia tortilis* (Musu) both at 29%.

Respondents used the nature of the leaves (dry vs wet), water content, health response of the animals following feeding, leaf colour, palatability, and seed and pod preference when judging browed plants as either good or bad sources of goat feed (Table 5). *Colophospermum mopane* (Mupani) (14%) and *Adansonia digitata* (Muvhuyu) (21%) were classified as bad sources of goat feed since, according to the respondents, goats would fall sick after browsing them. *Combretum apiculatum* (Musingizi) (29%) was classified as a good source of goat feed since according to the respondent's goats prefer its green leaves. Moreover, *Capparis tomentos* (Gwambazi) (21%) was mentioned as the most palatable feed material, while *Boscia albitrunca* (Muthobi) (50%) was preferred for its seeds and pods. Goat farmers used their indigenous knowledge to assess the quality of the identified fodder plants. A combination of criteria such as feed preferences, skin appearance, birth rate and weight gain as indicators of the nutritional quality of the fodder trees (Figure 2).

Colophospermum mopane was the most utilised browse species, while *Ziziphus mucronata* and *Maerua angolensis* were the least used browse species in the study area. Interestingly, results for chemical analysis indicated that *Maerua angolensis* had higher CP when compared to the other browse plants. Most of the browse plants reported in this study were classified as good sources for goat feed except for *Colophospermum mopane*, and *Adansonia digitata*, where the respondents had mixed views since consuming parts of these plant species was associated with the development of signs of ill health in animals. Makhado *et al*. (2016) and Makhado (2020) reported that green leaves of *Colophospermum mopane* possess high levels of secondary metabolites, such as tannins and phenols can lead to a loss of appetite and digestive problems. Additionally, Scogings *et al.* (2021) further stated that phenolic compounds reduce the palatability of plant leaves. *Adansonia digitate* was less popular among the respondents because its leaves are thick, and green and have a high-water content which could lead to digestive problems. Obidiegwu *et al.* (2020) reported that these green leaves contain high levels of anti-nutritional compounds such as phytic acid, oxalic acids, hydro carbonic acid and tannins. Several studies reported an association between the nutritional quality of the feed materials and the behaviour the animals exhibited in terms of high birth rate and weight gain (Cantalapiedra-Hijar *et al*., 2018; Patel *et al*., 2018; Oduro-Mensah *et al.*, 2020). However, no studies support the idea that an animal's skin response and feed selection (preference) are a criterion for the nutritional value of the field-available diet. As a result, in addition to laboratory analysis, there is a need to learn more about the nutritional assessment standards used by indigenous goat farmers in the rural areas of South Africa.

TABLE 3: Ranking by Utilisation of Identified Plant Species from the Most Utilised to the Least Utilised by Goats as Presented by Respondents in the Gumela Indigenous Goat Farming Area

Plant name	Rankings and Frequency (%)															
	Most 1	2	3	4	5	6	7	8	9	10	11	12	13	Least 14	15	Missing (%)
Colophospermum mopane (Mupani)	42.9	21.4	7.1	-	-	-	-	7.1	-	-	-	-	-	-	-	21.4
Adansonia digitata (Muvhuyu)	-	21.4	28.6	14.3	-	7.1	7.1	-	-	-	-	-	-	-	-	21.4
Sclerocarya birrea (Mufula)	-	14.3	28.6	14.3	7.1	-	14.3	7.1	-	-	-	-	-	-	-	14.3
Terminalia prunioides (Muṱwari)	28.6	7.1	-	21.4	7.1	-	-	7.1	-	-	-	-	-	-	-	28.6
Combretum apiculatum (Musingizi)	7.1	7.1	14.3	-	7.1	21.4	-	-	-	7.1	-	-	-	-	-	42.9
Senegalia galpinii (Munanga)	-	-	-	-	7.1	14.3	-	-	-	7.1	-	7.1	-	-	-	57.1
Capparis tomentos (Gwambazi)	-	7.1	-	7.1	-	-	7.1	7.1	-	-	14.3	-	-	-	-	42.9
Euclea crispa (Mutangule-Ngele)	-	7.1	-	-	7.1	7.1	7.1	7.1	7.1	-	-	-	-	-	-	64.3
Vachellia tortilis (Musu)	-	-	-	-	7.1	-	-	-	14.3	-	-	-	-	-	-	71.4
Dichrostachys cinerea (Murenzhe)	-	-	7.1	-	7.1	-	7.1	-	-	-	7.1	-	-	-	-	71.4
Boscia albitrunca (Muthobi)	21.4	-	-	14.3	-	-	-	-	-	-	-	7.1	-	7.1	-	50.0
Ziziphus mucronata (Mutshetshete)	-	-	-	-	7.1	-	-	-	7.1	-	7.1	7.1	-	-	7.1	64.3
Annona senegalensis (Muembe)	-	-	-	-	-	-	-	-	-	-	-	7.1	7.1	7.1	-	71.4
Maerua angolensis (Mutambanamme)	-	-	-	-	7.1	-	-	-	-	-	-	-	21.4	-	7.1	64.3
Cassine transvaalensis (Mulumanamana)	-	-	-	-	-	-	-	-	-	7.1	-	-	-	7.1	14.3	71.4

Missing (%): Percentage of farmers who did not state browsed plant species

Vol. 51 No. 1, 2023: 100-124
10.17159/2413-3221/2023/v51n1a13466

TABLE 4: Categorisation of Browsed Plant Species as Either Good or Bad Sources of Goat Feed by Respondents from Gumela Communal Goat Farming Area

Plant name	Frequency (%)		
	Good	Bad	Missing (%)
Colophospermum mopane (Mupani)	64.3	14.3	21.4
Adansonia digitata (Muvhuyu)	64.3	21.4	14.3
Sclerocarya birrea (Mufula)	85.7	-	14.3
Terminalia prunioides (Muṱwari)	71.4	-	28.6
Combretum apiculatum (Musingizi)	57.1	-	42.9
Senegalia galpinii (Munanga)	21.4	-	78.6
Capparis tomentos (Gwambazi)	57.1	-	42.9
Euclea crispa (Mutangule-Ngele)	42.9	-	57.1
Vachellia tortilis (Musu)	28.6	-	71.4
Dichrostachys cinerea (Murenzhe)	28.6	-	71.4
Boscia albitrunca (Muthobi)	50.0	-	50.1
Ziziphus mucronata (Mutshetshete)	35.7	-	64.3
Annona senegalensis (Muembe)	28.6	-	71.4
Maerua angolensis (Mutambanamme)	21.4	-	78.6
Cassine transvaalensis (Mulumanamana)	35.7	-	64.3

Missing (%): Percentage of farmers who did not state browsed plant species

10.17159/2413-3221/2023/v51n1a13466

TABLE 5: Reasons Given by the Respondents When Judging the Browsed Plants Species as Either Good or Bad Sources of Goat Feed

Plant name	Reasons and Frequency (%)						
	Dry leaves	High water	Sickness	Green leaves	Palatable	Seeds and pods	Missing (%)
Colophospermum mopane (Mupani)	28.6	-	14.3	14.3	7.1	-	28.6
Adansonia digitata (Muvhuyu)	7.1	28.6	21.4	-	7.1	-	21.4
Sclerocarya birrea (Mufula)	64.3	9.1	-	7.1	-	-	21.4
Terminalia prunioides (Muṱwari)	7.1	7.1	-	21.4	14.3	-	35.7
Combretum apiculatum (Musingizi)	21.4	-	-	28.6	-	-	50.0
Senegalia galpinii (Munanga)	7.1	7.1	-	7.1	7.1	-	64.3
Capparis tomentos (Gwambazi)	7.1	-	-	7.1	21.4	7.1	50.0
Euclea crispa (Mutangule-Ngele)	14.3	-	-	7.1	7.1	-	64.3
Vachellia tortilis (Musu)	-	--	-	7.1	-	28.6	71.4
Dichrostachys cinerea (Murenzhe)	-	-	-	-	-	7.1	74.4
Boscia albitrunca (Muthobi)	-	-	-	-	-	50.0	50.0
Ziziphus mucronata (Mutshetshete)	-	-	-	7.1	14.3	14.3	64.3
Annona senegalensis (Muembe)	-	28.6	-	-	-	-	71.4
Maerua angolensis (Mutambanamme)	-	14.3	-	-	7.1	14.3	64.3
Cassine transvaalensis (Mulumanamana)	7.1	-	-	7.1	7.1	-	71.4

Missing (%): Percentage of farmers who did not state browsed plant species

Vol. 51 No. 1, 2023: 100-124
10.17159/2413-3221/2023/v51n1a13466

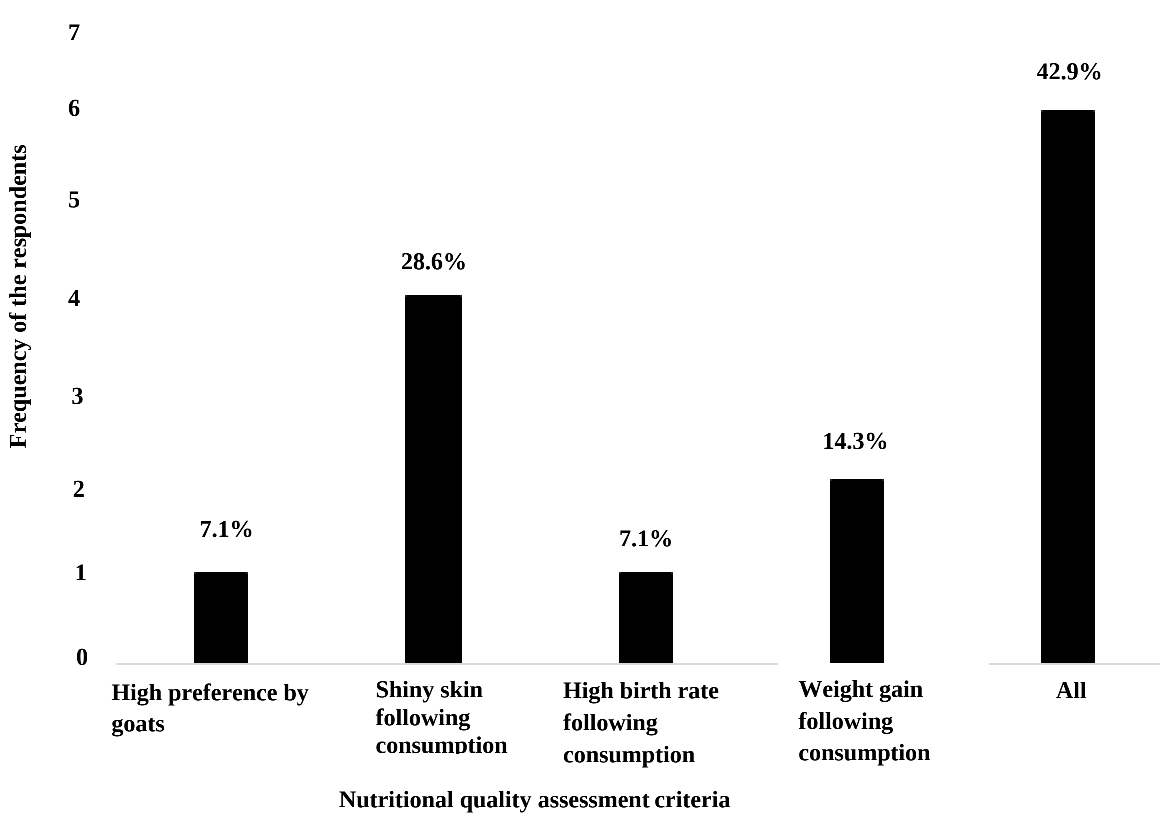

FIGURE 2: Feed Quality Assessment Criteria Used by Goat Farmers at Gumela Communal Goat Farming Area

5. CONCLUSION

The purpose of the study was to assess the knowledge of smallholder farmers regarding the identification and nutritional value of fodder trees that goats in the study area browse. Using a semi-structured questionnaire, 14 smallholder goat farmers were interviewed. The Animal Nutrition and Botany laboratories of the University of Limpopo in South Africa provided nutritional analysis and botanical identification services. The study results showed that the respondents had some knowledge of fodder plant materials browsed by their goats. It can be concluded from the present study's findings that most of the browse species reported in this study are good sources of goat feed since their CP levels were above the recommended minimum values. Generally, the respondents did not know how to determine the nutritional qualities of the available feed materials. For this reason, methods for determining the nutritional quality of fodder that are user friendly to the farmers can be developed and brought to the farmers through training programs

Vol. 51 No. 1, 2023: 100-124
10.17159/2413-3221/2023/v51n1a13466

by the extension officers. These initiatives would contribute towards the increased productivity of goats, hence contributing to improved livelihoods and food security in line with the National Development Plan 2030 of the South African government.

6. ACKNOWLEDGEMENTS

The authors are grateful to the Gumela smallholder goat farmers, especially the Ravhuanzwo brothers, for their assistance, Mr TP Maluta of the Limpopo Department of Agriculture and Rural Development for his co-ordination and the University of Limpopo's Department of Agricultural Economics and Animal Production.

REFERENCES

AL KAZMAN, B.S., HARNETT, J.E. & HANRAHAN, J.R., 2022. Traditional uses, phytochemistry and pharmacological activities of annonacae. *Mol.*, 27(11): 3462.

AOAC., 2005. *Official methods of analysis of the association of analytical chemists*. 18th ed. Washington, DC: AOAC.

AOAC., 2010. *Association of analytic chemists, official method of analysis*. 17th ed. Washington, DC; AOAC.

BERMAN, T.S., BEN-ARI, M., GLASSER, T.A., GISH, M. & INBAR, M., 2017. How goats avoid ingesting noxious insects while feeding. *Sci.*, 7(1): 1-10.

BROWN, D., NG'AMBI, J.W. & NORRIS, D., 2016. Voluntary intake and palatability indices of Pedi goats fed different levels of Acacia karroo leaf meal by cafeteria method. *Indian J. Anim. Res.*, 50: 41-47.

BROWN, D., NG'AMBI, J.W. & NORRIS, D., 2018. Effect of tanniniferous Acacia karroo leaf meal inclusion level on feed intake, digestibility and live weight gain of goats fed a Setaria verticillata grass hay-based diet. *J. Appl. Anim. Res.*, 46(1): 248-253.

BROWN, DJWN, N'GAMBI, JW & NORRIS, D., 2016. Feed potential of Acacia karroo leaf meal for communal goat production in southern Africa: A review. *J. Anim. Plant Sci.*, 26(4).

CANTALAPIEDRA-HIJAR, G., ABO-ISMAIL, M., CARSTENS, GE, GUAN, LL, HEGARTY, R., KENNY, DA, MCGEE, M., PLASTOW, G., RELLING, A. & ORTIGUES-MARTY, I., 2018.Biological determinants of between-animal variation in feed efficiency of growing beef cattle. *Animal.*, 12(2): 321-335.

COUCH, CE, WISE, BL, SCURLOCK, BM, ROGERSON, JD, FUDA, RK, COLE, EK, SZCODRONSKI, KE, SEPULVEDA, AJ, HUTCHINS, PR & CROSS, PC, 2021. Effects of supplemental feeding on the faecal bacterial communities of Rocky Mountain elk in the Greater Yellowstone Ecosystem. *PloS One.*, 16(4): 0249521.

DALLE, G., 2020. Evaluation of forage quantity and quality in the semi-arid Borana Lowlands, Southern Oromia, Ethiopia. *Trop. Grassl.*, *8*(2): 72-85.

DAS, M.M., RAM, S.N. & AHMED, A., 2021. Seasonal variation in nutrient sutilisation and growth performance of small ruminants under grazing on silvipasture system. *Indian J. Anim. Sci.*, *38*(2): 160-166.

DEPARTMENT OF AGRICULTURE, FORESTRY AND FISHERIES (DAFF)., 2019. *A profile of the South African goat market value.*

FAN, P., LIU, P., SONG, P., CHEN, X. & MA, X., 2017. Moderate dietary protein restriction alters the composition of gut microbiota and improves ileal barrier function in adult pig model. *Sci.*, *7*(1): 1-12.

FAYUM, IL, BUBA, CI, ATOGWE, J., OKEOMA, DC & EHIABHI, S., 2018. Phytochemical analysis, antioxidant activity and growth inhibitory effects of extracts from *Annona senegalensis*, walthleria indica and anthocleista vogelii. *Int. J. Pharmacogn.*, 5(11): 692-699.

GARCÍA-TORRES, L., BENITES, J., MARTINEZ-VILELA, A. & HOLGADO-CABRERA, A., 2003. *Conservation agriculture: environment, farmers' experiences, innovations, socio-economy, policy. The hot-dry seasoner*. United Kingdom.

Vol. 51 No. 1, 2023: 100-124
10.17159/2413-3221/2023/v51n1a13466

GEBREMEDHIN, A.T., GEDO, A.H., EDO, G.Y. & HAILE, S.T., 2020. Evaluation of multi-functional fodder tree and shrub species in mid-altitudes of South Omo Zone, Southern Ethiopia. *J. Hortic.*, 12(1): 27-34.

HABERMANN, E., DIAS DE OLIVEIRA, E.A., CONTIN, D.R., DELVECCHIO, G., VICIEDO, D.O., DE MORAES, M.A., DE MELLO PRADO, R., DE PINHO COSTA, K.A., BRAGA, M.R. & MARTINEZ, C.A., 2019. Warming and water deficit impact leaf photosynthesis and decrease forage quality and digestibility of a C4 tropical grass. *Physiol. Plant.*, 165(2): 383-402.

HABTE, M., ESHETU, M., ANDUALEM, D., MARYO, M. & LEGESSE, A., 2021. The inventory of camel feed resource and the evaluation of its chemical composition in south-east rangelands of Ethiopia. *Vet. Med. Sci.*, 7(4): 1172-1184.

HART, E.H., CHRISTOFIDES, S.R., DAVIES, T.E., REES STEVENS, P., CREEVEY, C.J., MÜLLER, C.T., ROGERS, H.J. & KINGSTON-SMITH, A.H., 2022. Forage grass growth under future climate change scenarios affects fermentation and ruminant efficiency. *Sci*, 12(1): 1-14

HIHOTO, W.D., ARLETTE, A., ROCK, D., ZAKI, B.G., CODJO, T.O., ZINSOU, C.K., ARSNE, J.F., GRARD, T., HYACINTHE, A. & ALEXANDRE, D., 2022. Assessment of proximal, mineral composition and content of vitamin A and C of leaves and flowers from *Lippia multiflora* vegetable in Benin. *Afr. J. Biotechnol.*, 21(3): 95-105.

HUNDAL, JS, SINGH, U., SINGH, N., KANSAL, SK & BHATTI, JS, 2016. Impact of training on knowledge level of goat farmers in Punjab. *H. Vet.*, 55(1): 47-49.

IBM Corp. (2017). *IBM SPSS Statistics for Windows (Version 25.0)* [Computer software]. IBM Corp.

IBRAHIM, K.H. & USMAN, L.A., 2021. Management practices of pasture, range and grazing reserves for livestock production in the tropics: A Review. *Am. Entomol.*, *5*(2): 18.

JIWUBA, P.C., NJOKU, C., AZODO, N.L. & AKAZUE, R.C., 2021. Nutrient intake, body weight changes, apparent nutrient digestibility and nitrogen utilisation of West African Dwarf goats fed four phytogenic browse plant parts in their diets. *Niger. J. Animal Sci.*, 23(2): 257-268.

KABIR, M.E., MIRAZ, F.H., ALAM, M.H., SARKER, M.B., HASHEM, A., KHANDOKER, M.Y., HUSAIN, S.S. & MONIRUZZAMAN, M., 2022. Dietary energy influences ovarian morphology and *in vitro* maturation of oocytes in goats. *J. Appl. Anim. Res.*, 50(1): 47-53.

KINLEY, RD, MARTINEZ-FERNANDEZ, G., MATTHEWS, MK, DE NYS, R., MAGNUSSON, M. & TOMKINS, NW, 2020. Mitigating the carbon footprint and improving productivity of ruminant livestock agriculture using a red seaweed. *J. Clean. Prod.*, 259: 120836.

LEITE, D.O., DE FA NONATO, C., CAMILO, C.J., DE CARVALHO, N.K., DA NOBREGA, M.G., PEREIRA, R.C. & DA COSTA, J.G., 2020. Annona genus: traditional uses, phytochemistry and biological activities. *Curr. Pharm. Des.*, 26(33): 4056-4091

LUGINBUHL, J.M., 2020. *Poisonous plants to livestock: Meat goats notes*. NC State Extension Publications. Available from https://content.ces.ncsu.edu/poisonous-plants-to-livestock

LUTHULI, CF, 2018. *Performance of Nguni goats supplemented with sweet potato vines*. Doctoral dissertation, University of Zululand.

MAKHADO, R.A., POTGIETER, M.J., LUUS-POWELL WJCOOPER, SM., OPPONG, C.K., KOPIJ, G., MUTISI, C. & MAKHABU, S.W., 2016. *Tragelaphusstrepsiceros* browse during the dry season in the mopani veld of Limpopo Province, South Africa. *Trans. R. Soc. South Africa*, 71: 17-21.

MAKHADO, R., POTGIETER, J.M. & LUUS-POWLL, W., 2016. Nutritional value of *Colophospermum mopane* as source of browse and its chemical defences against browsers: A review. *J. Anim. Plant Sci.*, 26(3).

MAKHADO, RA, 2020. Effects of various management control measures on seasonal leaf quality of colophospermum mopane and tragelaphus strepsiceros browse of C. mopane, Limpopo Province, South Africa.Doctoral dissertation, University of Limpopo.

MAMER, JTD, 2017. Evaluation of the nutritive value of selected South Sudan rangeland browses fed to crossbred growing goats.Doctoral dissertation, Egerton University.

MATHEW, JT, DAUDA, BEN, MANN A., NDAMITSO MM, ETSUYANKPA MB & SHABA EY, 2018. Assessment of the nutritive and anti-nutritive compositions of fermented and unfermented African custard apple (annona senegalensis) seeds from Niger state. *Niger. J. Sci. Technol. Eng. Mathe.*, 3(2): 471-477.

MBIRIRI, DT & OH, SJ, & CHOI, NJ, 2012, Effect of different silages for TMR on in vitro rumen simulative fermentation. *J. Kor. Grassl. Forage. Sci.*, 32(4): 379-386.

MEHMOOD, T., MAHMOOD, S., NAWAZ, MK & SHAFI, HMAMK, 2020. Forage preservation technology for sustainable livestock industry in rainfed areas of Pakistan: A review. *Pure. Appl. Biol.*, 9(3): 1849-1855.

MELLADO, M., 2016. Dietary selection by goats and the implications for range management in the Chihuahuan Desert: A review. *Rangel.*, 38(4): 331-341.

MUNICIPAL DEMARCATION BOARD (MDB)., 2015. *Determination of the boundary of Thulamela Local municipality by including the Gumela area. Development planning section. Feasibility Study.*

MUTIE, F.M., RONO, P.C., KATHAMBI, V., HU, G.W. & WANG, Q.F., 2020. Conservation of wild food plants and their potential for combatting food insecurity in Kenya as exemplified by the drylands of Kitui County. *Plnt.*, 9(8): 1017.

NAIR, MR, SEJIAN, V., SILPA, MV, FONSÊCA, VFC, DE MELO COSTA, CC, DEVARAJ, C., KRISHNAN, G., BAGATH, M., NAMEER, PO & BHATTA, R., 2021. Goat as the ideal climate-resilient animal model in tropical environment: Revisiting advantages over other livestock species. *Int. J. Biometeorol.*, 65(12): 2229-2240.

NATIONAL DEVELOPMENT PLAN (NDP)., 2012. National Development Plan 2030 of the South African government.

NELL, J.P. & VAN DER WALT, C., 2017. Horticultural development plan for the Thulamela Local Municipality. Environmental issues and environmental analysis.

NG'AMBI, J.W., ALABI, O.J. & NORRIS, D. 2013. Role of goats in food security, poverty alleviation and prosperity with special reference to Sb-Saharan Africa: A review. *Indian J. Anim. Res.*, 47: 1-9.

OBIDIEGWU, J.E., LYONS, J.B. & CHILAKA, C.A., 2020. The Dioscorea Genus (Yam)—An appraisal of nutritional and therapeutic potentials. *Foods.*, *9*(9): 1304.

ODURO-MENSAH, D., OCLOO, A., NORTEY, T., ANTWI, S., OKINE, L.K. & ADAMAFIO, N.A., 2020. Nutritional value and safety of animal feed supplemented with *Talaromyces verruculosus*-treated cocoa pod husks. *Sci.*, 10(1): 1-16.

RAMUKHITHI, F.V., NEPHAWE, K.A., LEHLOENYA, K.C., SESHOKA, M.M., JONKER, T., KOTZE, A., CHOKOE, T.C. & NEDAMBALE, T.L., 2018. sCharacterisation of seminal plasma constituents of unimproved indigenous and Tankwa goats. *S. Afr. J. Anim. Sci.*, 48(5): 943-953.

RIVERA-MÉNDEZ, C., PLASCENCIA, A., TORRENTERA, N. & ZINN, R.A., 2017. Effect of level and source of supplemental tannin on growth performance of steers during the late finishing phase. *Appl. Anim. Res*., 45(1): 199-203

ROUT, P.K. & BEHERA, B.K., 2021. Goat and Sheep Farming. In PK Rout & BK. Behera (eds.), *Sustainability in ruminant livestock*. Singapore: Springer, Singapore, 33-76

SAS., 2010. User's guide: Statistics. Cary, MC, USA: SAS Institute.

SCOGINGS, P.F., DEMMER, S. & HATTAS, D., 2021. Spinescence and total phenolic content do not influence diet preference of a critically endangered megaherbivore, but the Mix of compounds does. *J. Chem. Ecol.*, 47(3): 322-333.

WILLIAM, M., 2015. The potential sutilisation of Acacia Karroo in improving communal goat nutrition in the False Thornveld of the Eastern Cape Province, South Africa.Doctoral dissertation, University of Fort Hare.

WILLIAMS, ET, TIMOTHY, N. & CHIKA, A., 2019. Phytochemical screening, elemental and proximate analysis of *Maerua angolensis* (Capparaceaea) Stem bark. *Int. J. Biochem. Res. & Review*, 27(4): 1-10.

YOUSFI, I., SALEM, H.B., AOUADI, D. & ABIDI, S., 2016. Effect of sodium chloride, sodium sulfate or sodium nitrite in drinking water on intake, digestion, growth rate, carcass traits and meat quality of Barbarine lamb. *Small Rum.*, 143: 43-52.

YUSUF, A.O., EGBINOLA, O.O., EKUNSEITAN, D.A. & SALEM, A.Z.M., 2020. Chemical scharacterisation and in vitro methane production of selected agroforestry plants as dry season feeding of ruminant livestock. *Agrofor. Syst.*, 94(4): 1481-1489.