aJava

Asian Journal of Animal and Veterinary Advances

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS Asian Journal of Animal and Veterinary Advances

ISSN 1683-9919
DOI: 10.3923/ajava.2023.83.89

Research Article
Feed Intake, Live Weight Gain and Meat Quality of Galla Goats Fed Different Grasses

[1,2]Mathew Echopat Papa, [1]Wanzila Usyu Mutinda and [1]Edwin Nicholas Odongo

[1]Department of Animal Sciences, Pwani University, Kilifi, Kenya
[2]State Department for Livestock Development, Matuga Sheep and Goat Station, Matuga, Kenya

Abstract

Background and Objective: Livestock productivity is constrained by poor nutrition. The underlying factors that restrict productivity are poor feed quality and its unavailability, especially in the arid and semi-arid regions of Kenya. The use of alternative feed sources that are adapted to prolonged dry seasons is imperative. The effect of feeding different grasses on the feed intake, growth performance and taste of the meat of Galla goats raised in confinement was tested using 16 individually housed buckling male goats of 15.31±3.1 kg. **Materials and Methods:** In a Completely Randomized Block Design, the goats were blocked by initial weight and the four dietary treatments, namely Napier grass, *Brachiaria*, Rhodes grass and *Leucaena* (a control), were randomly assigned within each block. The experiment lasted 98 days. The experimental diet, mineral licks and water were offered *ad libitum*. Each goat was supplemented with 100 g/day of the dairy meal. **Results:** Feed intake was not significantly different between ($p>0.05$) goats fed Napier, *Brachiaria* or *Leucaena* but was significantly different ($p<0.05$) from goats fed Rhodes grass. Significantly higher weight gains ($p<0.05$) were observed in goats fed Napier and *Brachiaria* treatments. The goats fed Rhodes grass lost weight throughout the study. Treatments did not have an effect ($p>0.05$) on the taste, juiciness, or overall acceptability of the meat. Regarding the cooking method, roasting was the least preferred ($p>0.05$) in terms of the juiciness of the meat compared to boiling and frying. **Conclusion:** Therefore, Napier grass and *Brachiaria* could be used as an alternative feed for goats raised in confinement during dry periods.

Key words: Feed intake, live weight gain, Napier, *Brachiaria*, Rhodes, *Leucaena*, goat meat juiciness, taste, overall acceptability

Citation: Papa, M.E., W.U. Mutinda and E.N. Odongo, 2023. Feed intake, live weight gain and meat quality of galla goats fed different grasses. Asian J. Anim. Vet. Adv., 18: 83-89.

Corresponding Author: Wanzila Usyu Mutinda, Department of Animal Sciences, Pwani University, Kilifi, Kenya

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sheep and goats are kept for milk and meat production and constitute approximately 56% of the global domestic ruminant population[1]. However, goats not only survive under different agroecological conditions but can also use low-quality forages[2]. In the arid and semi-arid areas of Kenya, goats are generally reared in extensive production systems that depend on rangeland pastures that are deficient in nitrogen and other digestible nutrients such as protein, lipid and carbohydrate[3]. These low-quality feeds tend to negatively influence optimal rumen function, thus lowering voluntary feed intake[4].

Becker and Lohrmann[5] have observed that the growth performance of goats is influenced by various forages, which depends on the availability of vegetation and the selection of feed. For example, goats that received a diet consisting of Pangola grass along with a supplement of cotton seed cake experienced a greater increase in body weight[6]. Ngila *et al.*[7] reported an effect on the growth performance of galla bucklings fed different *Brachiaria* cultivars. In general, the quality and quantity of these feedstuffs affect feed intake, body weight gain and meat taste.

Napier grass (*Pennisetum purpureum*) is the most widely cultivated and used fodder crop in many parts of Kenya. It is valuable not only for Kenya but also for all tropical regions since grass is cut into small pieces and fed to livestock[8,9]. The grass is a strong perennial, cespitose, rhizomatous grass with sturdy rooting structures that grow from the nodes of its crawling runners. *Pennisetum purpureum* has many advantages, including that it has high biomass yields of vegetation throughout the year compared to other cultivated or natural grasses.

Rhodes grass (*Chloris gayana*) is indigenous to Africa and is distributed in the equatorial regions as a local variety and is cultivated in numerous habitations. It is tolerant to dry periods and its nutritional qualities are good in the early stages of growth with 8% CP, thus providing valuable and delicious fodder for livestock. The grass has adventitious roots and vertical stems and expands by root suckers with a compacted shoot base and a leaf capsule.

Brachiaria is the most useful equatorial grass crop indigenous to Africa. It is widely grown in parts of the Western Hemisphere, Australia, East Asia and even Brazil in South America. It has shown positive results where meat is being produced from pastures[10]. The *Brachiaria* plant gives a large amount of foliage biomass and has extensive root arrangements that are important for carbon sequestering into the soil. It can survive in dry and poor soils and provides various ecological advantages and biodiversity services[10,11].

Leucaena is a handy feed for ruminant animals, especially bovines, cattle, buffaloes and caprines. The fodder can be browsed, given fresh as cut-and-carry feed, or preserved as hay or silage to use later[12]. In addition, the use of leguminous feeds like *Leucaena* has been found to decrease greenhouse gas emissions in ruminant animals due to the presence of secondary compounds like tannins[13]. This is why *Leucaena* feed is commonly used in livestock diets because of its excellent nutritional properties, including a high protein content that varies between 24-34% depending on the species and time of year[14].

Meat is a complex and nutritionally significant component of human food. Its quality depends on many factors, among them the diet of the animal. Studies have shown that the diet is a significant determinant of carcass yield, cutability and other characteristics in various species, including goat[15-17]. The sensory qualities of meat are one of the primary factors that influence consumers' preferences. This study was conducted to determine the effect of feeding different grasses on the feed intake and live weights of Galla goats and the sensory quality of Galla goat meat.

MATERIALS AND METHODS

Study site: The study was carried out at the Matuga Sheep and Goat Breeding Farm in Kwale County, Matuga Sub County coordinates (4.17°S and 39.57°E) from June to September, 2018. The area is generally hot and dry from January to March, with June to August being chilly or cold. Kwale County receives an average of 1200 mm of rain annually and is bimodal, with long rains in March, April, May and short rains in October, November and December.

Experimental animals and management: In the study, 16 buckling Galla goats aged between 6 and 12 months with an average live weight of 15.31±3.1 kg were used. Each goat was assigned to a pen measuring 0.5×2.0 m and confined for 14 weeks. The goats were fed and handled according to the Standards and Guidelines of the Ethics Review Committee of Pwani University. The goats slept on raised timber perches to avoid contamination of the goats with urine and faecal matter. The animals were dewormed using levamisole before starting the experiment. The goats were also sprayed weekly with acaricide to control the ectoparasites.

Feeds and feeding: In a Complete Randomised Block Design, the 16 buckling Galla goats were blocked by initial weight and randomly assigned within each block to one of the four dietary treatments, that is, *Leucaena leucocephala* (control), Rhodes

Table 1: Chemical composition (%) of grasses and the dairy meal

Chemical composition	*Leucaena*	*Brachiaria*	Rhodes	Napier
Dry matter	84.2	84.7	84.6	86.6
Crude protein	26.6	16.4	8.90	13.6
Neutral detergent fibre	26.9	16.4	8.90	13.6
Acid detergent fibre	36.4	33.3	55.4	43.7
Acid detergent lignin	1.69	1.06	1.35	1.17
Calcium	1.30	0.36	0.00	0.00
Phosphorus	0.47	0.49	0.35	0.53
Potassium	3.77	4.39	4.87	5.31
Magnesium	0.21	0.18	0.00	0.00
Chemical composition of dairy meal				
Crude protein		14.61		
Moisture		11.52		
Fat		2.35		
Ash		7.26		
Fibre		7.73		
Starch		25.59		

grass, Ex-Tozi, *Brachiaria* hybrid Mulato II and Napier grass var French Cameroon. The experimental diets were chopped using a chaff cutter at a length of 5 cm before feeding to the goats. The chopped feed was thoroughly mixed to minimise the selection of the parts of the diet by the animals. The chemical composition (%) of the grasses and the dairy meal used in the study were presented in Table 1. Feed and water were provided *ad libitum*. All feed troughs were filled with weighed basal feed in the morning. If all the feed offered was consumed by nightfall, the feed offered the following day was adjusted to 120% of the previous day's intake for *ad libitum* intake. All the feed remaining in the troughs in the morning was collected, weighed and labeled as refused feed. Mineral licks were offered as a block per pen for the animals to lick freely. Furthermore, the animals were supplemented with 100 g/day of Fugo dairy meal from Unga Feeds Kenya Ltd.

The goats were allowed a 14-day adaptation period before data collection began. The data collected were the amount of feed consumed in grams per day and the weight gain in grams per day for 98 days. After 98 days of treatment, one goat from each treatment was randomly selected and slaughtered to determine the effect of dietary treatments on the taste, juiciness and overall acceptability of Galla goat meat using three cooking methods i.e., boiling, frying and roasting.

Data collection-feed intake and animal live weights: Daily feed intake was estimated from the difference between the weight of feed offered and the weight of feed refused. The average live weight gain of each goat per week was calculated as the difference between the initial and final weights at the end of each week and the average daily gain by dividing the change in weight by the number of days (98 days).

Slaughter, meat sample collection and preparation: On day 98, one goat was randomly selected from each dietary treatment for slaughter. The goats were not fed for 12 hrs before slaughter, however, clean drinking water was provided *ad libitum.* The goats were slaughtered using standard procedures: Bleeding, skinning, evisceration and washing. The meat sampled for evaluation was from the muscle of the distal hind limbs. The samples were cut into small pieces weighing approximately 2 g, mixed uniformly and subjected to different cooking methods, that is, boiling, roasting and frying.

Cooking methods: The cooking methods tested were boiling, frying and roasting. The boiling cooking method was done by placing randomly selected cut meats in a deep metal cooking pot with a flat base filled with 1 L of water. The cooking pot was then placed on a charcoal burner and heated for 25 min. Frying involved placing the cut meat in a saucepan, adding 4 mL of cooking oil and placing the saucepan over the burning charcoal for at least 20 min and roasting involved placing cut meat pieces on a wire mesh on a charcoal burner for at least 25 min. No seasonings or spices (including salt) were added[18]. The boiled, fried and roasted meats were placed on individual pre-labeled plates for tasting by the sensory panelist.

Sensory evaluation: Ten people served as a panelist in the sensory evaluation of the meat, as done in previous similar experiments[19]. The panelists were staff from the Kwale County Livestock Production Department and Kenya Agricultural and Livestock Research Organization at Matuga. The staff was trained before evaluating and tasting the sampled meat. A five-point Likert scale of juiciness, taste and overall

acceptability was used to evaluate the samples, with 5 referring to extremely like and 1 extremely dislike[20]. A translucent cloth was used to blindfold the tasters. The mouth of each taster was rinsed before and after each sample. A toothpick was used to pick a sample and give the taster. Chewing was done to determine the sample ranking, which was recorded immediately and then spat into a dustbin. The taster was not allowed to swallow the sample after tasting it.

Statistical analysis: Data on feed intake and weekly weight gain were analyzed in a Complete Randomized Block Design using PROC MIXED of SAS using the model:

$$Y_{ij} = \mu+\alpha_i+\beta_j+\varepsilon_{ij}$$

where, Y_{ij} is the dependent variable, μ is the overall mean, α_i is the effect of treatment (i = 1, 2, ... , 4) (Napier, Rhodes, *Brachiaria* and *Leucaena*), β_j is the effect of the block (j = 1, 2,.., 4) and ε_{ij} is the random residual error. Means were separated using Tukey's Test and significant differences were declared at a probability of $p<0.05$.

The data on sensory evaluation of meat were also analyzed in a Complete Randomized Block Design using PROC MIXED of SAS as above[21]. However, because count data typically follow a Poisson distribution where the mean is equivalent to the variance, the linear models used above which are based on normal distributions may not be appropriate[22]. As a result, the data were first transformed by taking the square root of the frequencies that the panelists recorded for each treatment before the data were analyzed.

RESULTS AND DISCUSSION

Voluntary feed intake: The voluntary feed intake of the goats was low during the first 4 weeks of the experiment, then increased from week 5 to week 14 (Table 2 and Fig. 1). The low feed intake observed during the first 4 weeks of the study could be attributed to the adjustment period as the goats adapted to new conditions and feed. The feed intake of goats under different treatments ranged from 7.8-13.9, 7.5-15.1, 2.1-4.4 and 8.3-15.1 kg/week for *Leucaena*, *Brachiaria*, Rhodes and Napier grass, respectively, as shown in Fig. 1. The feed intake of goats fed Rhodes grass was significantly lower than that of those fed Napier grass, *Brachiaria*, or *Leucaena*.

This could be attributed to the difference in the nutritional composition of the feeds (Table 1). Catanese *et al.*[22] showed that discrepancies in feed intake among animals fed different diets could be explained by differences in feed preferences. Ruminants, when presented with a selection of feed, can choose the most nutritious options. All feeds in this study had the minimum crude protein range of 6-8 % CP required by the animals for maintenance[23]. Although feed intake was initially low in all treatments in this study, it increased steadily, an observation like that of Ngila *et al.*[7] when he fed goats on Mulato II (*Brachiaria* cultivar).

Live weight gains: Live weights of goats fed Napier grass, *Brachiaria*, or *Leucaena* were not significantly different (Fig. 2 and Table 3). However, they had a difference in live weights that could be attributed to the different nutritional values and chemical composition of the basal diets.

The range of nutrient composition of these three treatments was almost the same (Table 1). Rhodes grass had low crude protein and low neutral detergent fibre. The goats fed Rhodes grass lost weight throughout the experimental period, this concurs with a study by Ondiek *et al.*[24] in which small East African goats fed Rhodes grass had negative growth rates. In the current study, goats fed Napier grass had a higher weight gain, which contrasts with observations made by Kaitho and Kariuki[25], Low daily weight gain and dry matter intake in goats fed only Napier grass[26]. This could be due to differences in the crude protein levels used. In the study by Kaitho and Kariuki[25] the crude protein was low compared to the current study, where the crude protein of Napier grass was higher. Muhammad Rusdy[26] reported that goats fed only Napier grass lost body weight. This could be due to environmental and physical factors that are possible attributes of variation in the quality of forages[7] reported an initial daily weight loss of goats for the first 10 weeks and a steady daily weight gain in goats fed *Brachiaria*, an observation like this study.

Table 2: Average weekly feed intakes (Mean±Standard deviation) for goats fed different dietary treatments

Dietary treatment	Weekly dry matter (kg) (Mean±Standard deviation)
Leucaena (control)	11.8±2.56[a]
Rhodes grass	3.40±0.85[b]
Brachiaria grass	11.7±2.27[a]
Napier grass	12.2±2.44[a]

[ab]Means in the same column with different superscripts are significantly different at ($p<0.05$)

Table 3: Average weight change for goats fed different treatments

	Treatment			
Parameter	*Leucaena*	Rhodes grass	*Brachiaria*	Napier grass
Initial weight (kg)	13.72±2.14	16.76±2.26	14.8±2.22	15.97±2.30
Final weight (kg)	16.74±2.36	16.17±2.32	18.27±2.47	17.93±2.45
Total weight gain	3.02[a]	-0.59[b]	1.47[a]	1.96[a]

[ab]Means in the same row with different superscripts are significantly different at ($p<0.05$)

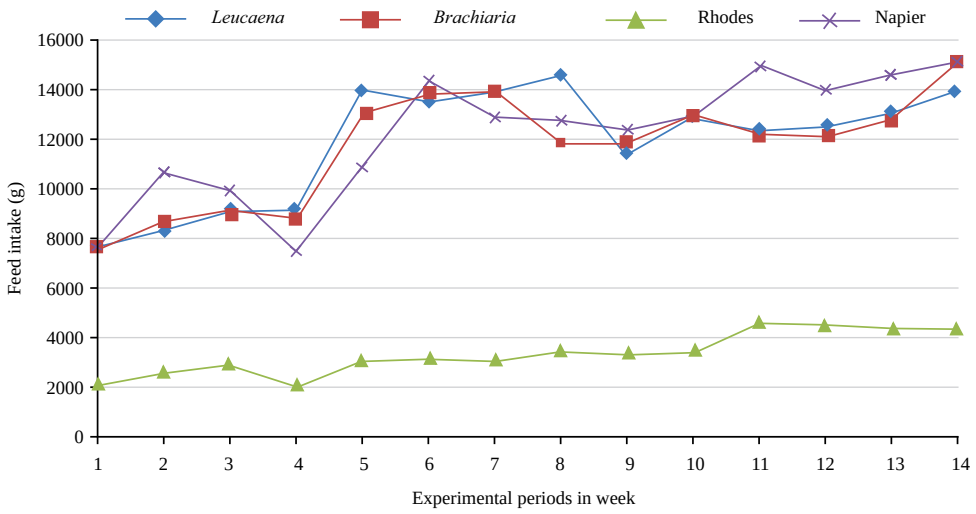

Fig. 1: Average voluntary weekly feed intake of goats

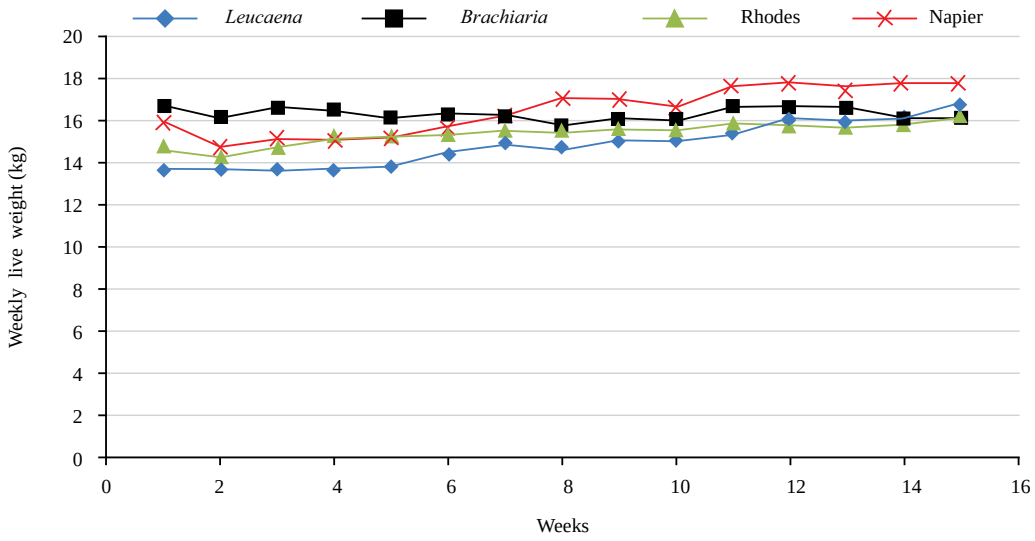

Fig. 2: Average weekly live weight gains of goats

Meat quality: The flavor is a combination of taste and smell (aroma). In this study, the taste of the roasted and boiled goat meat was significantly different in *Brachiaria*-fed goats. This difference was not significant for goats fed Rhodes, Napier and *Leucaena*. Based on the taste of fried goat meat, it was clear that goats fed Rhodes grass had a significant difference, but it was not evident with goats fed *Leucaena*, *Brachiaria*, or Napier. The juiciness of meat is directly related to the intramuscular lipids and the moisture content of meat[27]. The juiciness of the roasted goat meat in this study had a significant difference in the goats that were fed Rhodes grass. The difference was not evident for goats fed *Brachiaria*, Napier, or *Leucaena*. The cooking method did not affect the taste of goat meat and overall acceptability. This observation contrasted with that of Mbato *et al.*[18] who observed that chicken meat was tastier when fried and roasted than when boiled. The cooking method did not affect the juiciness of goat meat when fried or boiled, but the difference was evident with the juiciness of roasted meat, as it was the least preferred (Table 4).

More moisture and less heat are produced when meat is boiled. Consumers evaluate cooked meat quality based on tenderness, juiciness and flavor. The difference was only

Table 4: Effect of the cooking method on the juiciness of goat meat of goats fed *Leucaena*, *Brachiaria*, Rhodes and Napier grass

Cooking method	Mean	SE	p-value
Boil	1.8334[b]	0.0741	0.0258
Roast	1.6750[a]	-	-
Fry	1.8560[b]	-	-

[ab]Means in the same column with different superscripts differ significantly at p<0.05 and SE: Standard error

observed in the cooking method, where roasting was the least preferred in juiciness because the meat was drier. Goat meat is naturally lean, very nutritious and has many health benefits. It is internationally regarded as a healthier alternative to other red meats such as beef, lamb and pork with favorable nutritional characteristics[28]. Meat has less saturated fat, more iron and about the same amount of protein as pork, lamb, beef, or chicken.

CONCLUSION

The study found that Napier and *Brachiaria* grasses had a positive impact on the feed intake and live weight of Galla goats. As a result, these grasses can serve as a viable alternative feed for *Leucaena*, especially in areas where browse plant species are limited.

SIGNIFICANCE STATEMENT

Over 80% of Kenyans depend on agriculture for their livelihoods and smallholder farmers rely heavily on livestock production. However, low productivity due to poor-quality feeds is a common problem, especially during the dry season. Smallholder farmers face feed shortages due to seasonal availability and a lack of capital and arable land. Improving feed management could significantly increase productivity, reproductive performance and health status of livestock. The objective of the study was to determine the effect of feeding different grass cultivars on feed intake, growth performance and meat quality of Galla goat meat raised in confinement. The study showed that Napier grass and Brachiaria could be used as alternative feed for goats raised in confinement during dry periods.

ACKNOWLEDGMENTS

The authors thank the Director of Livestock Production for allowing the experiments to be conducted at Matuga Sheep and Goat Breeding Station. The authors also acknowledge Mr. Japhet Ngombo and Saidi Tsuma, who attended the animals and assisted in data collection. This study was funded by the Pwani University Research Fund, grant no. 15.

REFERENCES

1. Marino, R., A.S. Atzori, M. D'Andrea, G. Iovane, M. Trabalza-Marinucci and L. Rinaldi, 2016. Climate change: Production performance, health issues, greenhouse gas emissions and mitigation strategies in sheep and goat farming. Small Ruminant Res., 135: 50-59.
2. Abedo, A.A., Y.H. Hafez, E.I. Khalifa, B.K. Mohamed and O.A. El-Zolaky, 2013. Milk yield and composition of dairy Zaraibi goats fed microbial inoculated corn silage. Egypt. J. Sheep Goat Sci., 8: 141-151.
3. Ngugi, R.K. and D.M. Nyariki, 2005. Rural livelihoods in the arid and semi-arid environments of Kenya: Sustainable alternatives and challenges. Agric. Hum. Values, 22: 65-71.
4. van Soest, P.J., 1994. Nutritional Ecology of the Ruminant. 2nd Edn., Cornell University Press, London, UK, ISBN: 978-1-5017-3235-5, Pages: 476.
5. Becker, K. and J. Lohrmann, 1992. Feed selection by goats on tropical semi-humid rangeland. Small Ruminant Res., 8: 285-298.
6. Nyako, H.D., I.H. Malgwi, A. Kibon, M.M. Yahya, S. Abdullahi, I.M. Aminu and I.I. Gabdo, 2015. Performance of yankasa rams offered a basal diet of pangola grass hay supplemented with different supplements in the semi-arid zone of North East of Nigeria. Int. J. Dev. Res., 5: 5044-5047.
7. Ngila, P., D.M. Njarui, N.K. Musimba and M. Njunie, 2016. Performance of galla goats fed different cultivars of *Brachiaria* in the coastal lowlands of Kenya. J. Fish. Livest. Prod., Vol. 5. 10.4172/2332-2608.1000210.
8. Singh, B.P., H.P. Singh and E. Obeng, 2013. Elephant Grass. In: Biofuel Crops: Production, Physiology and Genetics, Singh, B.P. (Ed.), CABI International, Wallingford, Oxfordshire, England, ISBN: 978-1-78924-377-2, pp: 271-291.
9. Abdulrazak, S.A., E.G. Njuguna and P.K. Karau, 2005. The effect of supplementing Rhodes grass (*Chloris gayana*) hay with *Acacia tortilis* leaves and pods mixture on intake, digestibility and growth performance of goats. Livest. Res. Rural Dev., Vol. 17.
10. Mutimura, M. and S. Ghimire, 2021. *Brachiaria* Grass for Sustainable Livestock Production in Rwanda under Climate Change. In: Handbook of Climate Change Management: Research, Leadership, Transformation, Filho, W.L., J.M. Luetz and D. Ayal (Eds.), Springer International Publishing, Cham, Switzerland, ISBN: 978-3-030-57280-8, pp: 195-211.
11. Djikeng, A., I.M. Rao, D. Njarui, M. Mutimura and J. Caradus *et al*., 2014. Climate-smart *Brachiaria* grasses for improving livestock production in East Africa. Trop. Grasslands-Forrajes Tropicales, 2: 38-39.
12. de Angelis, A., L. Gasco, G. Parisi and P.P. Danieli, 2021. A multipurpose leguminous plant for the mediterranean countries: *Leucaena leucocephala* as an alternative protein source: A review. Animals, Vol. 11. 10.3390/ani11082230.

13. Jayanegara, A., F. Leiber and M. Kreuzer, 2012. Meta-analysis of the relationship between dietary tannin level and methane formation in ruminants from *in vivo* and *in vitro* experiments. J. Anim. Physiol. Anim. Nutr., 96: 365-375.
14. Fariña, S.R., S.C. Garcia and W.J. Fulkerson, 2011. A complementary forage system whole-farm study: Forage utilisation and milk production. Anim. Prod. Sci., 51: 460-470.
15. Shija, D.S., L.A. Mtenga, A.E. Kimambo, G.H. Laswai and D.E. Mushi *et al*., 2013. Chemical composition and meat quality attributes of indigenous sheep and goats from traditional production system in Tanzania. Asian Australas. J. Anim. Sci., 26: 295-302.
16. Warmington, B.G. and A.H. Kirton, 1990. Genetic and non-genetic influences on growth and carcass traits of goats. Small Ruminant Res., 3: 147-165.
17. Webb, E.C. and P. Pophiwa, 2017. Goat Meat Production in Resource-Constrained Environments and Methods to Improve Quality and Yield. In: Sustainable Goat Production in Adverse Environments: Volume I, Simões, J. and C. Gutiérrez (Ed.), Springer International Publishing, Cham, Switzerland, ISBN: 978-3-319-71854-5, pp: 195-209.
18. Mbato, P.A., T.O. Rewe and N.E. Odongo, 2018. Effect of free-range strategy on taste of conventional broiler meat in coastal lowlands of Kenya. Adv. Anim. Vet. Sci., 7: 5-11.
19. Keskin, S., A. Kor and S. Karaca, 2012. Evaluation of sensory characteristics of sheep and goat meat by procrustes analysis. Czech J. Anim. Sci., 57: 516-521.
20. Yeu, K., Y. Lee and S.Y. Lee, 2008. Consumer acceptance of an extruded soy-based high-protein breakfast cereal. J. Food Sci., 73: S20-S25.
21. Quinn, G.P. and M.J. Keough, 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press, Cambridge, UK, ISBN: 9780521009768, Pages: 537.
22. Catanese, F., R.A. Distel, R.M.R. Iglesias and J.J. Villalba, 2010. Role of early experience in the development of preference for low-quality food in sheep. Animal, 4: 784-791.
23. Minson, J.D., 1980. Nutritional Differences Between Tropical and Temperate Pastures. In: Grazing Animals, Morley, F.H.W. (Ed.), Elsevier, Amsterdam, Netherlands, pp: 143-157.
24. Ondiek, J.O., S.A. Abdulrazak and E.N. Njoka, 2010. Performance of growing small East African goats offered rhodes grass hay and supplemented with a 1:1 mixture of *Maerua angolensis*: *Zizyphus mucronata* leaf browses. Livest. Res. Rural Dev., Vol. 22.
25. Kaitho, R.J. and J.N. Kariuki, 1998. Effects of desmodium, sesbania and calliandra supplementation on growth of dairy heifers fed napier grass basal diet. Asian Australas. J. Anim. Sci., 11: 680-684.
26. Rusdy, M., 2018. A review of the effects of quality forage supplementation on growth performance of cattle and goats fed elephant grass basal diet. Livest. Res. Rural Dev., Vol. 30.
27. Lonergan, S.M., D.G. Topel and D.N. Marple, 2019. The Science of Animal Growth and Meat Technology. 2nd Edn., Academic press, Cambridge, Massachusetts, ISBN: 978-0-12-815277-5.
28. Muchenje, V., K. Dzama, M. Chimonyo, P.E. Strydom, A. Hugo and J.G. Raats, 2008. Sensory evaluation and its relationship to physical meat quality attributes of beef from Nguni and Bonsmara steers raised on natural pasture. Animal, 2: 1700-1706.