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Promoting improved forages for increased livestock productivity in the Arid and Semi-Arid Lands (ASALs) of Kenya: A case of Kajiado, Narok and Taita Taveta County

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Abstract

Inadequate nutrition is a major constraint that negatively impacts the growth and viability of cattle farming in Kenya's arid and semi-arid lands (ASALs). This is hastened by the adverse effects of climate change that lead to feed scarcity and poor-quality feed. However, these impacts can only be checked with the use of improved technologies hence the need to disseminate adaptation strategies and technologies. In an attempt to resolve the situation, Kenya Agricultural and Livestock Research Organization (KARLO) in partnership with SNV Netherlands Development Organization agencies instituted a research program; Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes Kenya's (ICSIAPL) and established demonstration plots across highlands and lowland regions in Kajiado, Narok and Taita Taveta counties. This paper focused on evaluating forage nutritive value and its impact on livestock productivity through testing changes in milk yield and animal acceptability for selected grasses and legumes that were promoted. All the grasses established in the lowland regions (*Brachiaria camello*, Nutrifeed, Sugar graze, Foxtail, *Panicum maximum* var Maasai) and legumes (cowpea, *dolichos lablab* and crotalaria) had crude protein above the critical level of 70kg/Dm except Sugargraze which had a Crude protein of 48 kg /Dm. The test animals showed high acceptability to Nutrifeed (83%) relative to the sugar graze (50%) and recorded 33% and 25% increase in milk when fed on nutrifeed and Sugargraze respectively. The highland grasses (*Brachiaria cobra*, *Brachiaria cayman*, Boma rhodes, *Panicum maximum* var Siambaza) and legumes (Desmodium, Lucerne, purple vetch, sweet potato vines and Mucuna) were also high in nutritive quality with *Panicum maximum* var Siambasa having high animal acceptability of 75% relative to *Brachiaria cobra* with 20%. Desmodium had animal acceptability rate of 80%.and recorded 23% increase in milk yield. The results inform that legume species promotes animal performance and should thus be included while feeding to boost the production for sustainable ruminant productivity under ASALs ecosystems.

Keywords: Acceptability, quality, legumes, livestock productivity, milk yield, scarcity

Introduction

Livestock production is the major source of livelihood in arid and semi-arid lands (ASALs) of Kenya. It accounts for 90% of employment and more than 95% of family income (Njiru *et al.*, 2010) [21]. However, it is largely constraint by scarcity of quantity and quality of feed which is influenced by rainfall and temperature seasonality exposing major ASAL regions to drought and claiming 80% of livestock mortalities (Muriithi, 2018) [22]. In addition, this seasonality poses a major impact on the forage quality thus reducing livestock production potential. These call for the need to employ strategies towards improved livestock productivity through disseminating improved feed and forage options, evaluating the forage yield and quality, and impact on livestock productivity parameters (Ayele *et al.*, 2012) [3]. These improved forages include perennial grasses and legumes planted for grazing or cut and carry (Rao *et al.*, 2015) [16] and should be incorporated in production system to supplement the feed base

The nutritional quality of forages is measured using its nutritive composition with major elements being crude protein (CP), energy, minerals and fibre (NDF, ADF) components as they are reliable measures of nutritional quality (Ganskoop & Bohnert, 2001) [8] in forages.

Seventy (70) g/kg CP level in diet is considered as critical threshold for the maintenance of ruminant livestock (NRC, 2000) [14]. The critical crude protein level in diet is required for maximum growth and activity of ruminal microorganisms thus producing desired microbial crude protein (MCP) amounts and maximum ruminal fermentation. However, CP concentration in plants is influenced mainly by the supply of available N in soil and the stage of maturity at harvesting. On the other hand, Minerals are required to meet the animal requirements for optimum development and health (McDowell, 2003) [13]. Growing beef requires calcium (Ca) level of 4.5 g/Kg Dm, Phosphorus (P) of 3.0 g/Kg Dm and Copper level of 10 g/KgDM (McDowell, 2003) [13]. The critical NDF values are in the range of 600-650 g/Kg Dm (vansoest *et al*., 1991) [19] for optimal functioning of rumen microbiota and 250-350 g/Kg Dm for lactating cows (NRC, 2001) [15]. Higher NDF values affects dry matter intake (DMI) and increases with longer harvesting interval

The major forage feed available for livestock in ASALs includes annual and perennial grasses, legumes, multipurpose trees and shrubs. These predominant and adaptable forages fail to support increased productivity. These is because they are low in biomass yield and poor in quality, which necessitated introduction of improved fodder on farm and in the existing feeding regimes with higher biomass yield, better quality and adaptable to adverse climate in efforts to increase ruminant productivity. The resulting impact can only be seen in increase in animal product since milk and meat production amongst pastoral communities is adversely affected, leaving the community at risk of food insecurity. To assess the impact of improved forage on livestock dairy animals are used because it rapidly translates to higher milk yield as long as a cow has sufficient genetic potential (Lascano, 2001) [12].

This study proceeded on addressing the feed scarcity by disseminating improved feed and forage options to farmers in the ASALs, evaluating their yield and quality, and impact on livestock productivity of different forages established in lowlands and highland regions of Taita Taveta, Narok and Kajiado County. The results inform that legumes need to be incorporated into the diet while feeding ruminants on low-quality grasses to boost productivity for sustainable ruminant productivity under ASALs ecosystems.

Materials and Methods

Study sites

The study was conducted on the demonstration plots established in highland and lowland sites in the counties of Narok, Kajiado and Taita Taveta located in the southern rangelands of Kenya. The counties are predominantly ASAL. The rainfall pattern in all the counties is bimodal distribution. Kajiado County receives as little as 300mm around the Amboseli basin to as high as 1250 mm per annum in Ngong' hills and Mt. Kilimanjaro slopes (CGK, 2018) [4]. Similarly, the rainfall in Narok County ranges from 500-2500 mm per annum (CGN, 2020) [5] while Taita Taveta county receives a rainfall of 340mm to 1200mm per annum (CGT,18) [6]. The soils in most of the study sites were varying with most soils being low in organic matter.

Sampling of the forage species for analysis

The forage samples under study were of 7 grass pastures (*Brachiaria camello*, Bush rye, Nutrifeed, African foxtail, *Brachiaria cayman*, Sugargraze & *Panicum maximum* var Maasai) and 3 legumes (Cow pea, *Dolichos lablab* and crotalaria) established in the lowland regions. Four grass pastures (*Brachiaria cobra*, Boma rhodes, *Brachiaria cayman* and *Panicum maximum* var Siambaza) and five legumes (Desmodium, Lucerne, Purple vetch, Sweet potato vines and Mucuna) were established in the highlands regions. Demonstration plot measured 100 m^2 across the counties of Narok, Kajiado and Taita Taveta during the short rains, October to December 2021 and long rains of March to May 2022. The plots were monitored continuously and weeds, insects, and diseases and pests, and other probable external sources of variation were maintained at minimal levels.

Samples for the experiment were collected randomly using one-meter square quadrats, by clipping to ground level all the above-ground vegetation when at bloom stage for biomass yield and for nutritive analysis. The grasses were dried under a shade until transported to the Laboratory of Arid and Rangelands Research Institute (ARLRI), where they were oven-dried at 65 ºC for 48 hrs and ground to pass through a 1-mm sieve in a mill.

Determination of the nutritive composition of the forage species

The ground samples of each forage species were taken to laboratories of the university of Nairobi college of Agriculture and veterinary sciences for nutritive content analysis. The following nutritive analysis was to determine; True DM (at 105 ºC for 24 hr) in an air-forced oven (Genlab Oven, Genlab Ltd, UK.); Total nitrogen (N) content was also determined by the Kjeldahl procedure (AOAC, 1990, method no. 988.05) [2] using selenium catalyst tablets. The crude protein content was estimated by multiplying the total N by a factor of 6.25. Further, samples were analyzed for neutral detergent fiber (NDF) and acid detergent fiber (ADF) according to AOAC, (1990) [2] method number 6.5.1 and 6.5.2 respectively, using an Ankom 200 fiber analyzer (Ankom Technology cooperation, Fairport, USA). ME was calculated using NRC 2001 [15] equation (ME Mcal/Kg =1.01*DE-0.45). And a factor of 4.19 was used to convert Mcal/Kg to MJ/Kg.

Mineral content was estimated by combusting the sample in a muffle furnace at 550 ºC for 5hrs (HeraeusM110 muffle furnace, Heraeus Holding GmbH, Hanau, Germany). This was according to AOAC method (AOAC, 1990 method no.924.05 [2]. Ashes were digested in a solution containing HCl and HNO_3, using the wet digestion technique. Concentrations of Calcium, Copper and Selenium were determined by atomic absorption spectrophotometry whereas, Phosphorus was quantified spectrophotometrically following AOAC, 1997 [1] procedure.

Determination of feeding value of selected forages

The forages were harvested at bloom (50% flowering) stage for quality and feeding value testing using selected dairy cattle in milk. The forages were prepared before presenting to the animal by chopping to 2-3 mm length. The animals for the test were offered feed in a cafeteria feeding system as described by Larbi *et al*., (1993) [23] and allowed to do self-selection. Acceptability of the feed was judged based on the time taken eating a particular feed, the number of times a particular feed was visited and the amount of feed eaten verses refusals. Further, the selected cattle were offered 5kg of fresh feeds just before milking for five days. Changes in milk yield were noted and records made for five days.

Experimental design and statistical analysis

This study employed a Completely Randomized Design. The forage species were the treatments, while the nutritive value, acceptability and animal response were treated as dependent variables.

The model used was as follows;

$$Y_{ij} = \mu + T_i + \varepsilon_{ij} \quad \text{(iii)}$$

Where,

Y_{ij}=observation on nutritive value /acceptability/animal response of ith forage species on j^{th} replication

μ= overall mean,

T_i= fixed effect of the forage species i

ε_{ij}=residual error

Data was subjected to General Linear Model procedure on GENSTAT to determine the significance between the grass species' nutritive value and the means separated with Tukey HSD at a 5% significant level.

Results

Nutritive value composition: Fig 1 and Fig 2 shows the nutritive values determined for the sampled forage species established in the highlands regions across the study counties. All the forages in Taita Taveta and Narok highlands had a crude protein in the range of 110-130 g/Kg Dm with *Brachiaria Cobra* having the highest CP among the established grasses in Narok (168.4 g/Kg Dm) while Extozi which was not planted in Narok had an even higher CP content of 193.2 g/Kg Dm in Taita-Taveta County. Among the legumes, Mucuna registered the highest CP content in both counties; 236.2 and 227.2 g/Kg Dm in Narok and Taita Taveta respectively though the rest of the legumes also had a relatively high CP. *Boma rhodes and Panicum maximum* var Siambasa established in Taita Taveta and Narok highland regions were found to have high NDF value of 843 g/Kg Dm and 692 g/Kg Dm respectively. On the other hand, *Brachiaria cobra* and *Brachiaria cayman* in the highlands of Narok had NDF values of 618 and 622 g/Kg Dm respectively. The NDF values for all the legumes were within the range of 400-500 g/Kg Dm except for desmodium, purple vetch and mucuna in Narok Highlands whose NDF values were beyond 500 g/Kg Dm. The ADF values for all the forages were within the range of 330-410 g/Kg Dm. ME for all the forages was above 8Mj/Kg.

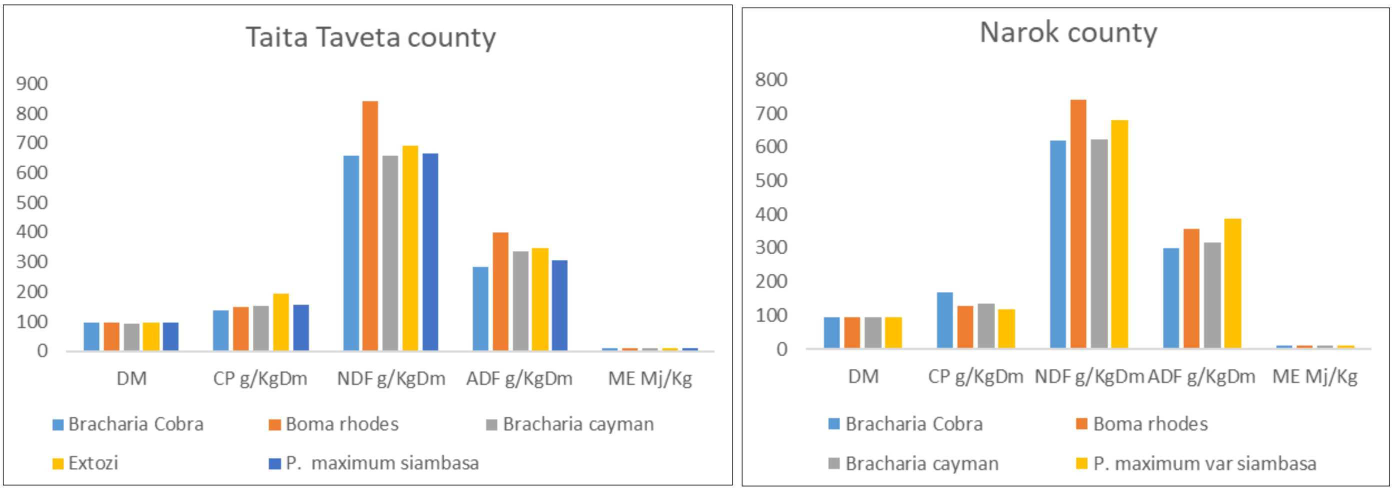


Fig 1: Nutritive compositions of grass pastures established in Highland regions of Narok and Taita Taveta counties

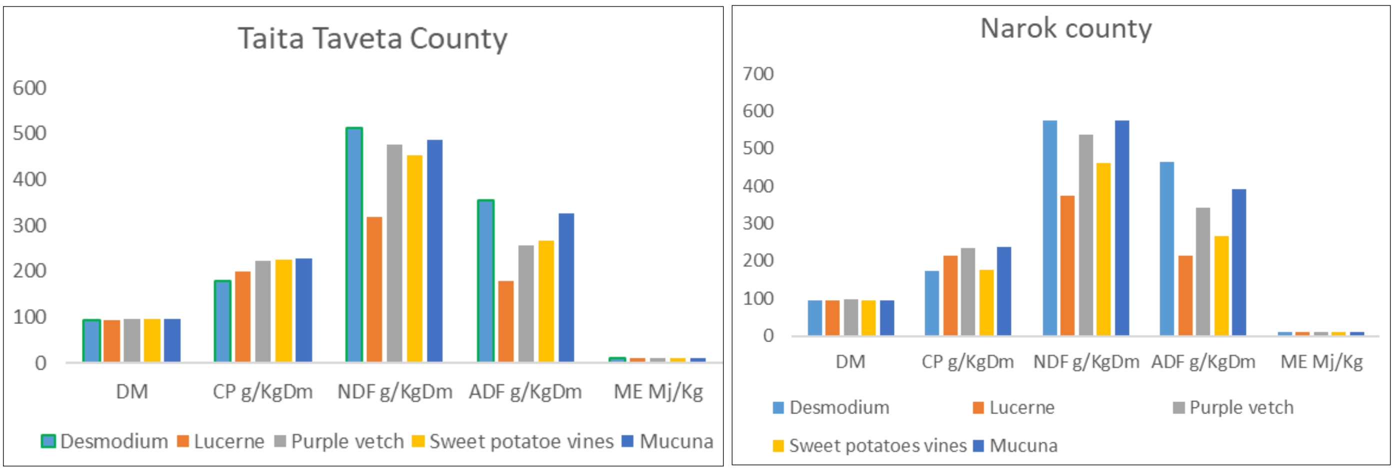


Fig 2: Nutritive composition of legumes established in Highland regions of Narok and Taita Taveta counties

Fig 3 & 4 presents all the forages established in lowland regions of Kajiado, Taita Taveta and Narok counties. All the forages were found to have a high crude protein value which was above 70 g/Kg Dm. The Foxtail had 194 and 175 g/Kg Dm CP levels in Kajiado and Narok lowlands. sugar graze in Taita Taveta County had a low crude protein content of 480 g/Kg Dm. Bush rye, *Brachiaria camello, Brachiaria cayman,* Foxtail and Sugargraze were found to have a high NDF value above 650 g/ Kg Dm. This was not the case for Nutrifeed which was found to have NDF value of 566 g/Kg Dm. The

NDF value for all legumes was within the range of critical value 400-500 g/Kg Dm. ADF values were low for all the forages ranging between 247-399 g/Kg Dm for grasses and 256- 405 g/Kg Dm for legumes. All forages studied had ME value beyond the minimum requirement of 8Mj/Kg.

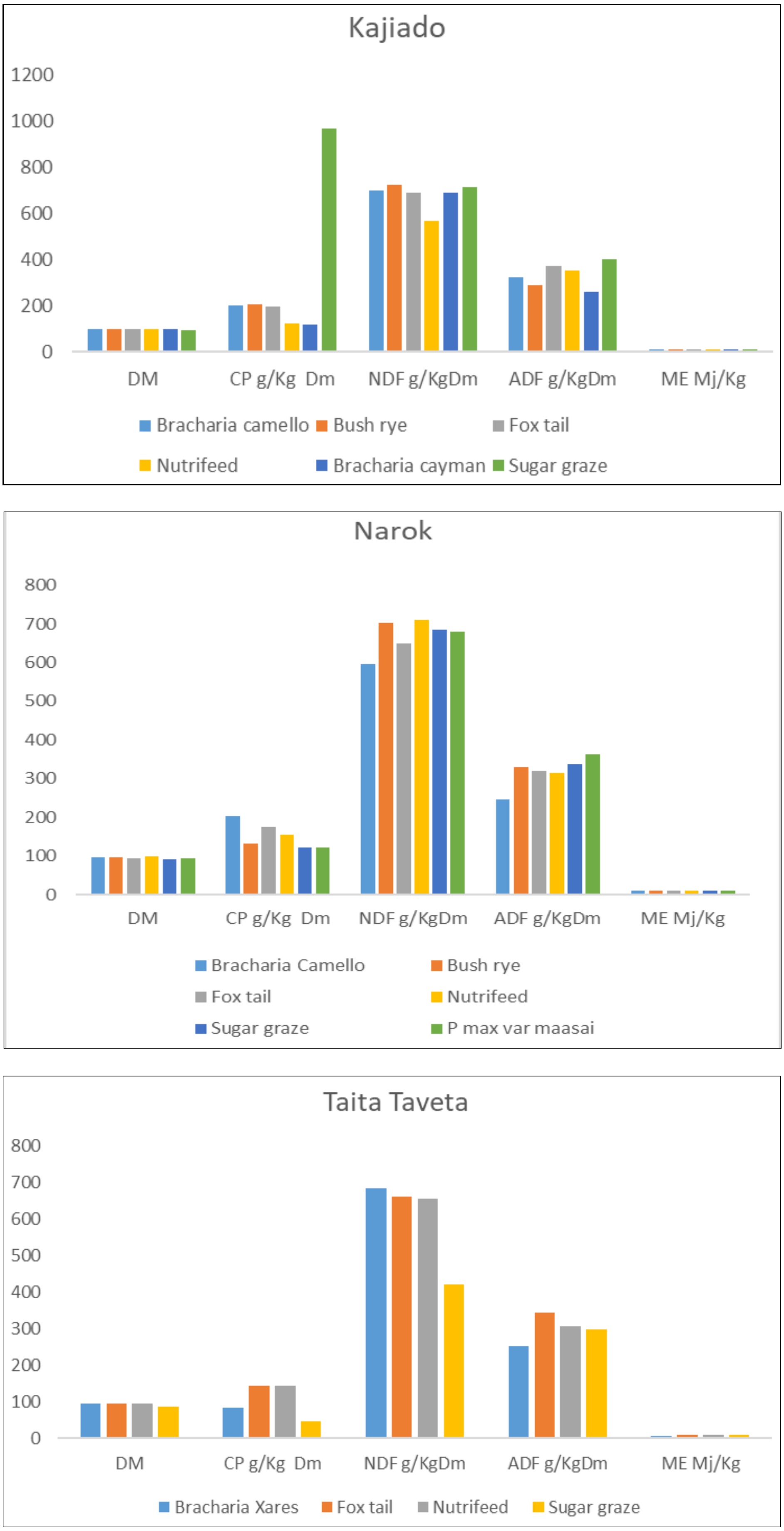


Fig 3: Nutritive value of grass species established in lowland region of Kajiado, Narok and Taita Taveta counties

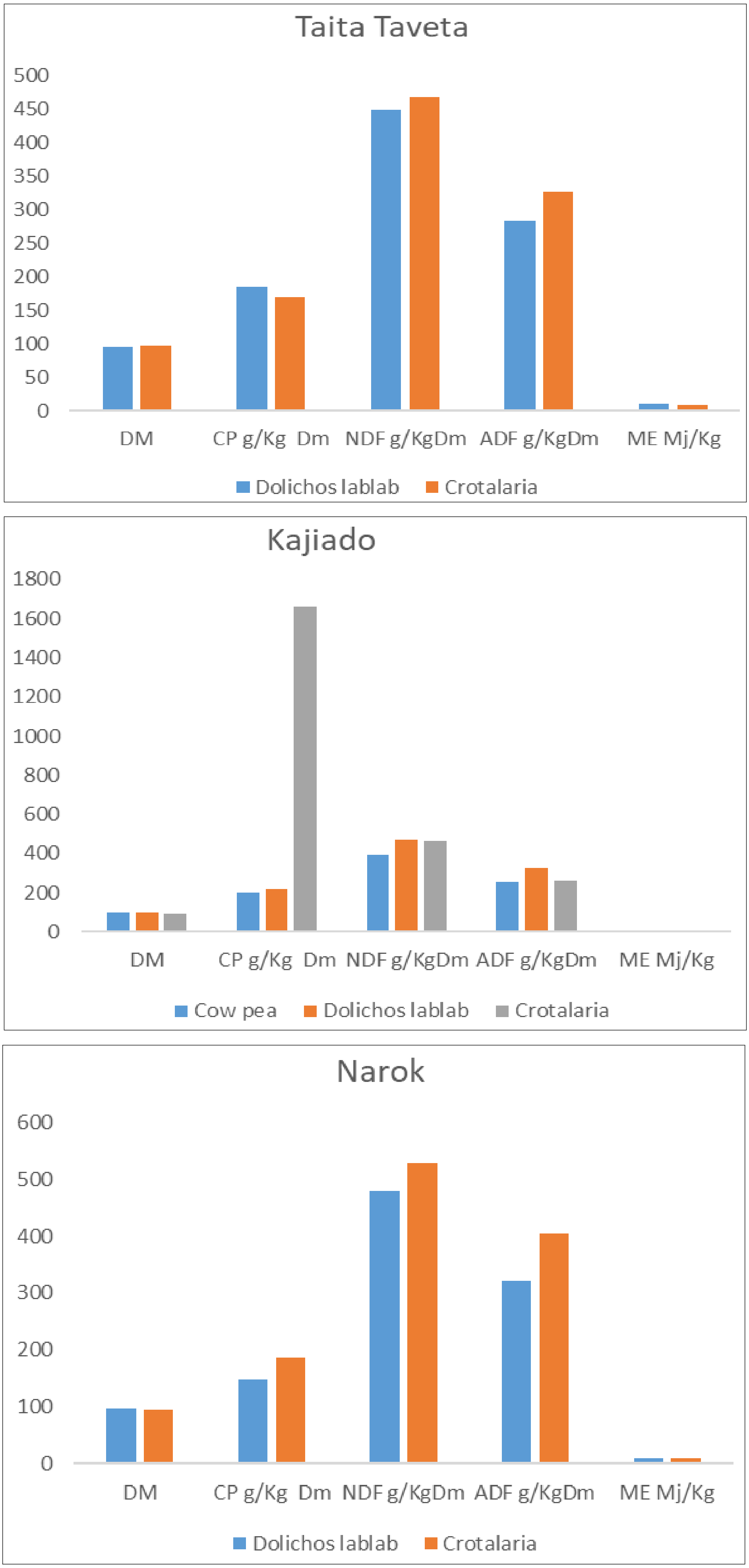


Fig 4: Nutritive value of legume species established in lowland region of Kajiado, Narok and Taita Taveta counties.

Fig 5 and fig 6 shows mineral content of studied forages established in the highland regions. The mineral values were varied with calcium (ca) ranging between 0.5 – 2.8 g/Kg Dm for grasses and 3.5 – 6.6 g/Kg Dm for legumes, copper (Cu) between 0-60g/Kg Dm for grasses and 10-70g/Kg Dm for legumes, Phosphorus (P) between 2.0 - 4.8 g/Kg Dm for grasses and 2.3- 5.3 g/Kg Dm for legumes; Selenium (Se) between 0-9 g/Kg Dm for grasses and 1-6 g/Kg Dm for legumes

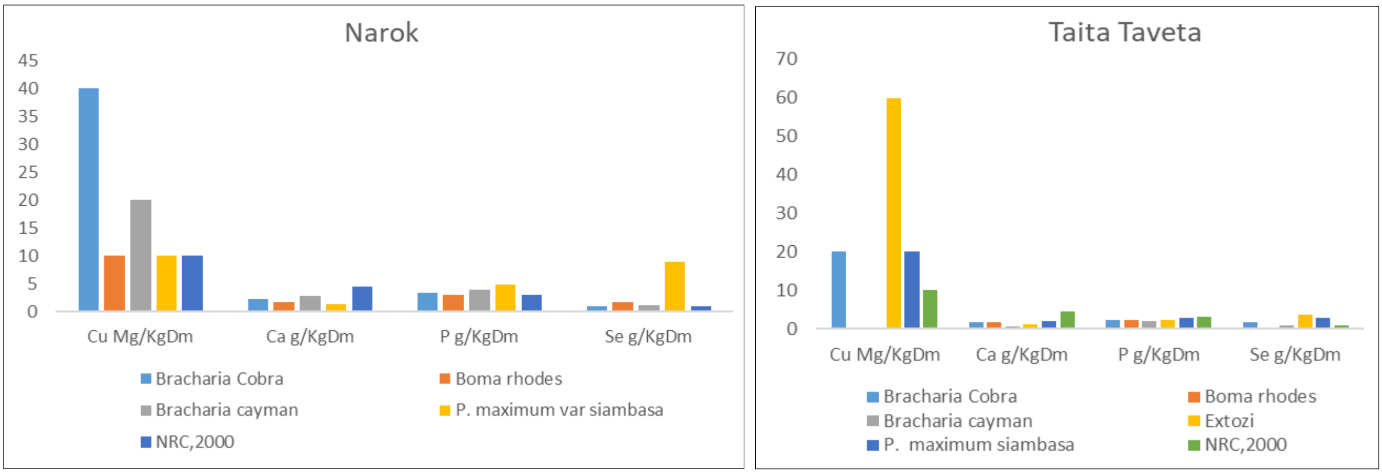


Fig 5: Mineral composition of grass pastures studied in Highland regions of Taita Taveta and Narok counties relative to NRC, 2000 [14] requirement for beef cattle

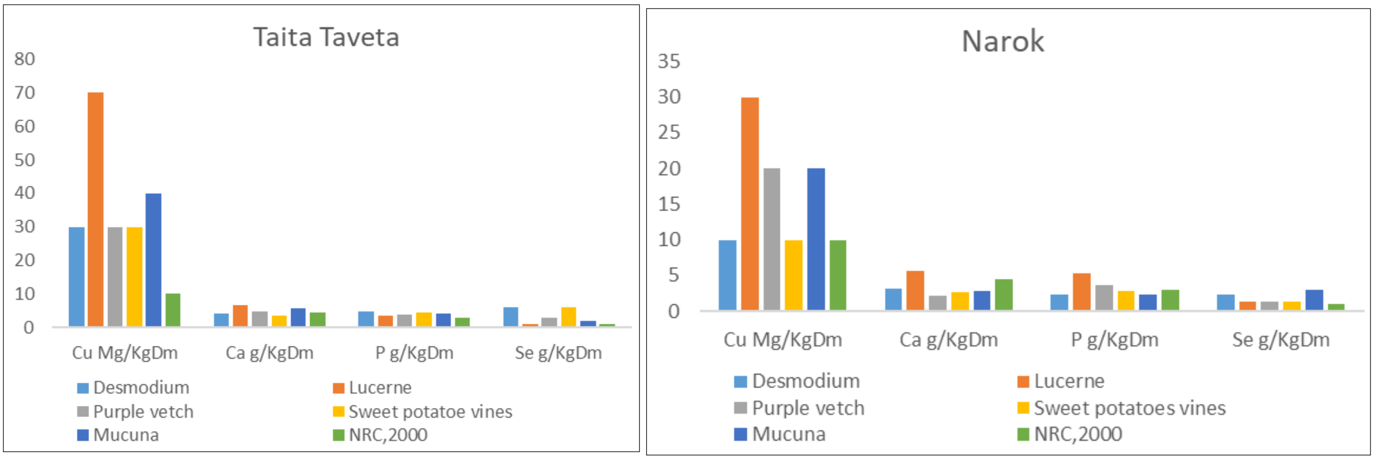
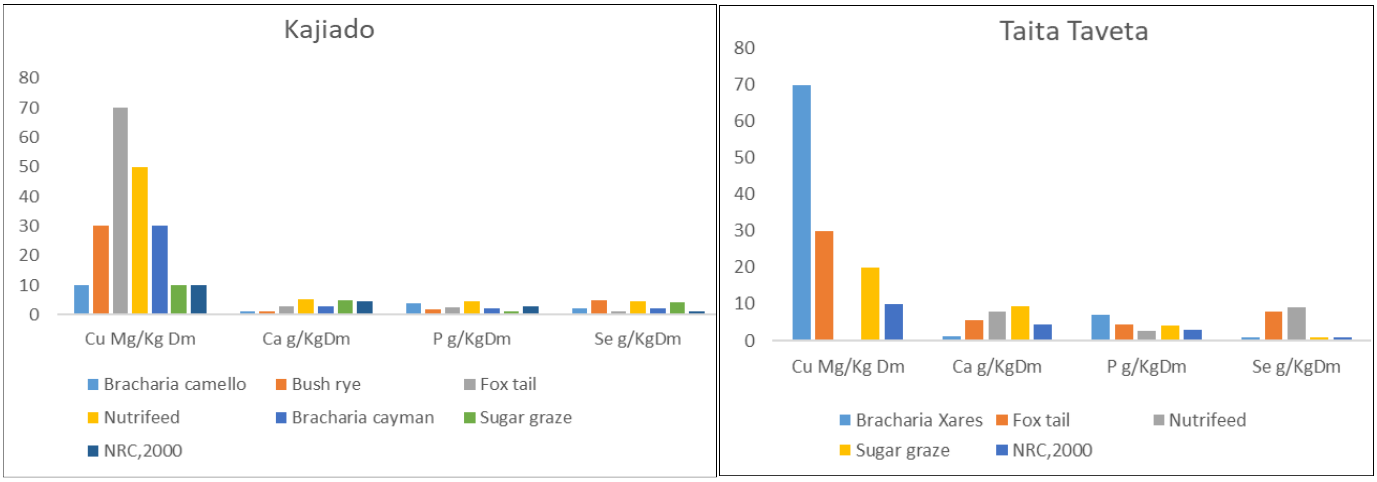


Fig 6: Mineral composition of legumes studied in Highland regions of Taita Taveta and Narok counties relative to NRC, 2000 [14] requirement for beef cattle

Fig 7 and fig 8 shows mineral composition among studied forages established in the lowland regions, the mineral values were varied with calcium (ca) ranging between 1.0 -9.3 g/Kg Dm for grasses and 1.4 – 10.6 g/Kg Dm for legumes, copper (Cu) between 10-70g/Kg Dm for grasses and 20-60g/Kg Dm for legumes, Phosphorus (P) between 1.2 -8.5 g/Kg Dm for grasses and 1.5 to 7.0 g/Kg Dm for legumes; Selenium (Se) between 1-9 g/Kg Dm for grasses and 1-7 g/Kg Dm for legumes



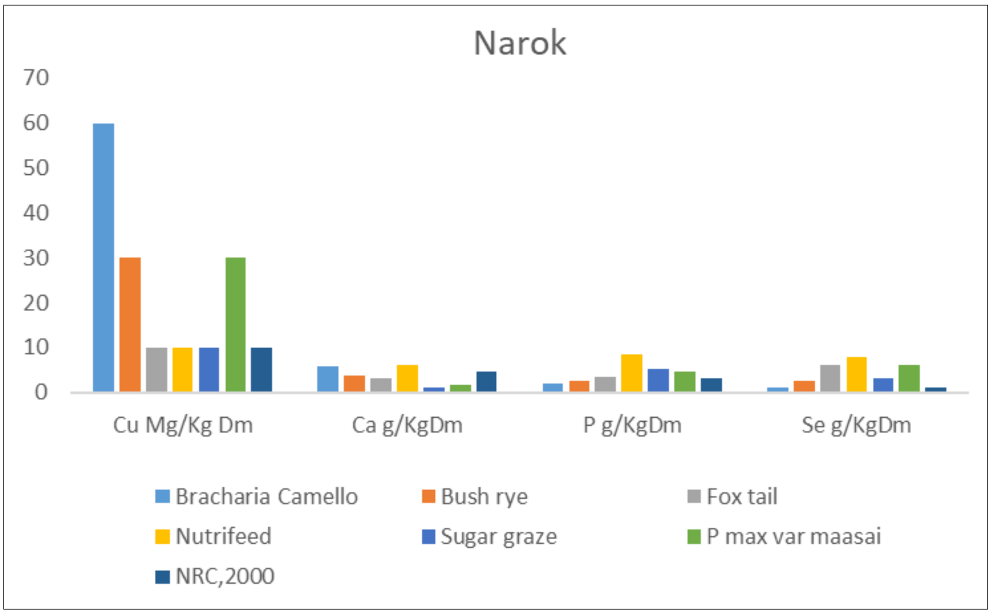
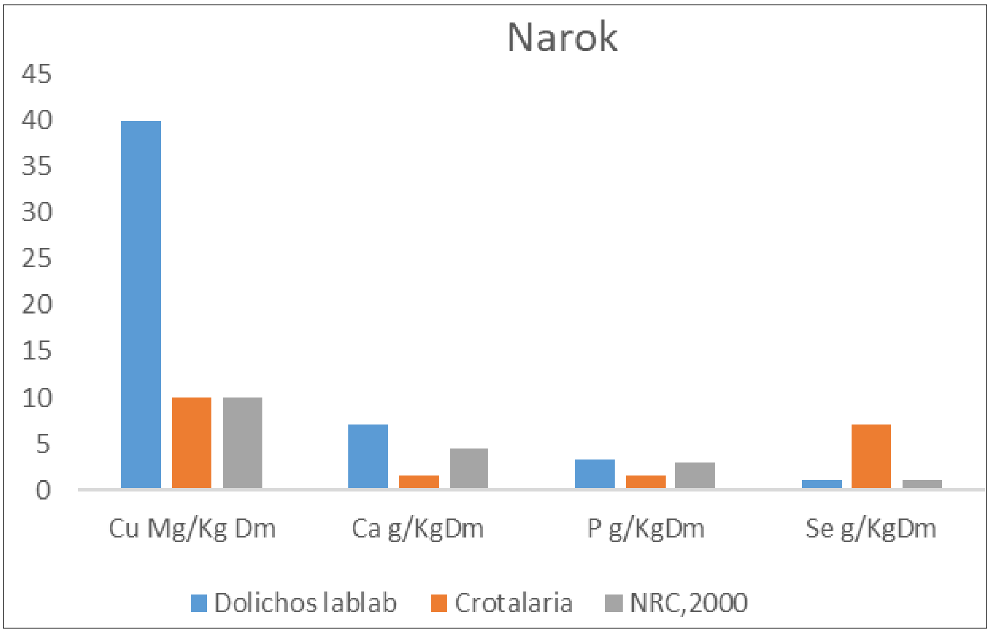
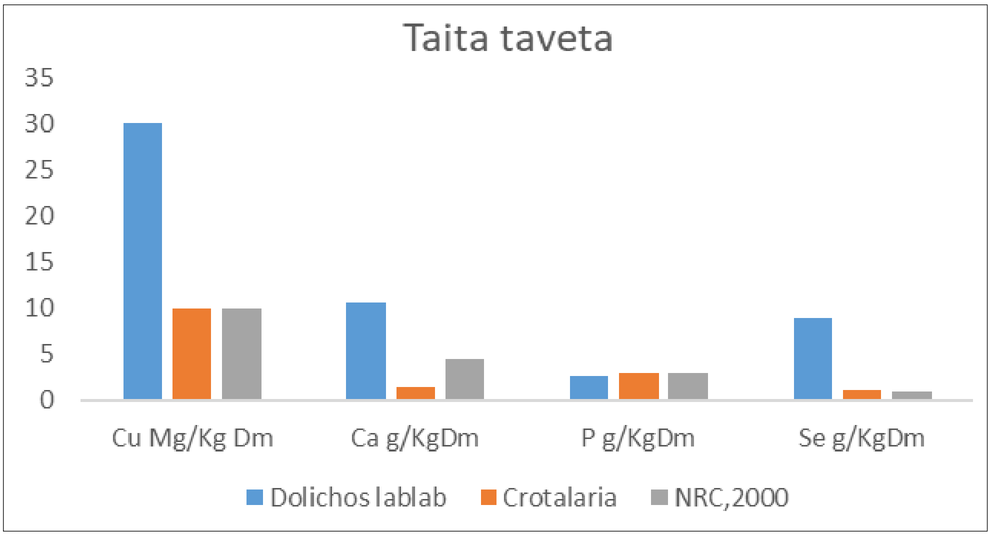


Fig 7: Mineral composition of grass pastures studied in lowland regions of Kajiado, Taita Taveta and Narok counties relative to NRC, 2000 [14] requirement for beef cattle





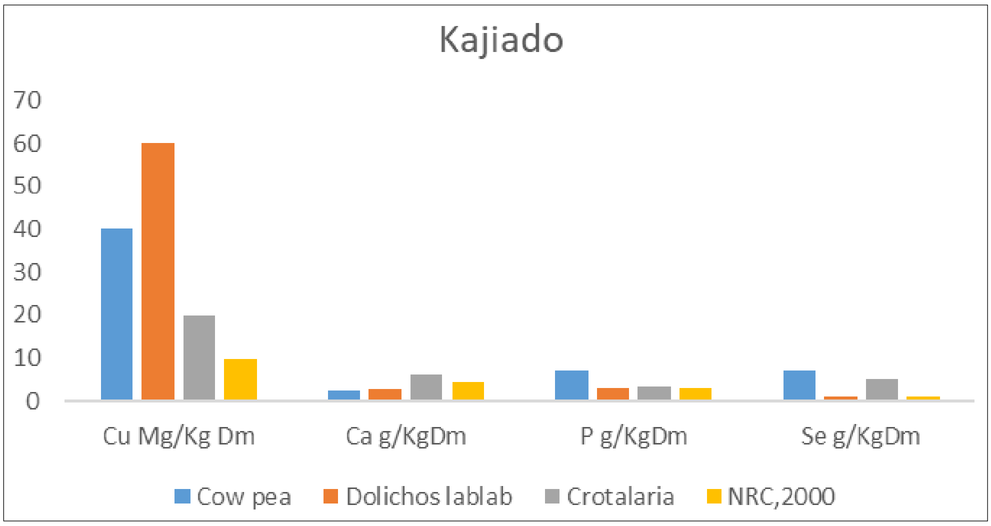


Fig 8: Mineral composition of legumes studied in lowland regions of Kajiado, Taita Taveta and Narok counties relative to NRC, 2000 [14] requirement for beef cattle

Animal performance as a result of feeding selected forages

Fig 9 shows the performance of sampled forage species established in the highlands and lowlands regions across the three counties. On average, animals fed on nutrifeed recorded the highest response in milk with 33% increase while *P. maximum* recorded the least with 18.3% increase. In terms of acceptability Nutrifeed was found the best with 83% acceptability rate while *Brachiaria cobra* was least accepted On the side of the legumes, clotoraria was highly accepted by the test animal with acceptability rate of 90% followed by desmodium 80% and dolichos lablab 62.5% all the legumes recorded 23% increase in milk

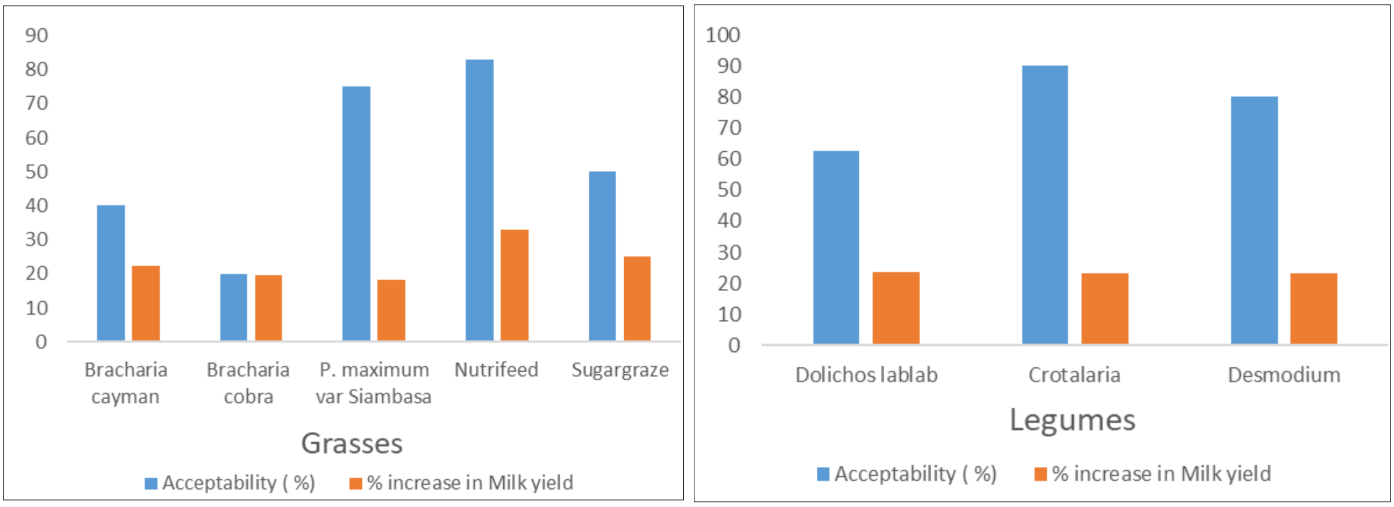


Fig 9: Overall performance (acceptability and milk response) of the tested forages

Discussions

The CP content of all the forages (grasses and legumes) established in demonstration plots in the low land and highland regions of the study counties was above the minimum requirement for rumen microorganism of 70 g/Kg DM (van - soest 1994) [20], and within the recommended values required for the maintenance of beef cattle (NRC, 2000) [14]. The CP levels were also above the minimum CP of 100–120g/Kg DM required for dairy cattle in order to maintain adequate rumen function and dry matter intake (DMI) (Lean *et al*., 2014) [11] since Lactating cows require more CP (160–190 g/Kg DM) according to their level of milk production, body weight, pregnancy status, and milk composition (NRC, 2001) [15]. All the studied forages could meet the recommended CP requirement except for Sugargraze (48 g/Kg Dm) and *Brachiaria xares* (85 g/Kg DM*)* established in lowland regions of Taita Taveta whose CP content was below the recommended threshold. The low CP of sugar graze and *Brachiaria xares* is likely to supply sub optimal nitrogen level in the rumen, restrict microbial growth and activity (Hariadi *et al*., 2010, NRC, 2000) [14] and consequently reduce feed intake and efficient ruminal activity. Although the CP content is a consistent measure of nutritional quality (Ganskoop and Bohnert, 2001) [8] in forages it is influenced by supply of available N in soil and stage of maturity at harvesting. Thus, soil amendments and harvesting stage should be checked while producing forages.

The NDF value of the grasses established in both highland and lowland regions was beyond the critical values recommended for efficient animal requirement 600- 650 g/Kg DM (van soest *et al*., 1991) [19]. This could signify lower intake and low digestibility of feed (Doreau *et al*., 2016) [7] hence reduced animal productivity. The NDF value for all legumes was within the range of critical value 400-500 g/Kg Dm. According to NRC, (2001) [15], lactating cows require a minimum NDF value of 250-350 g/Kg DM so the studied forages could supply high NDF values which may affect DMI negatively. Katoch *et al*. (2022) [10] in their study reported 319-354g/Kg DM as the ADF values for the tropical pastures but for the studied grasses it was relatively higher and ranged between 247-399 g/Kg DM for grasses and 256- 405 g/Kg Dm for legumes. In addition, all the ADF values were above the minimum recommended ADF for lactating cows of 170-210 g/Kg DM (NRC, 2001) [15]. The ME of all the forages in this study were above the minimum requirement of 8.8 Mj/Kg DM for beef cattle (NRC, 2000) [14] and NRC, 2001 [15] recommended value for lactating cows of 8.4-10.3 Mj/Kg DM, these implies that the forages could supply optimal energy levels for ruminants.

The studied forages had varied levels of mineral content required to meet the animal needs for optimum development and health and also has an influence to animal productivity (McDowell, 2003) [13]. Growing beef cattle require about 4.5 g of Ca/kg DM in their diets (McDowell, 2003) [13]. It seems that most of the forages in lowland regions (Nutrifeed, Sugar graze, *dolichos lablab* and *Brachiaria camello*) had Ca level above the requirement for beef cattle while only a few had insufficient Ca to meet these requirements. The P levels were also varied with only few forages meeting the P requirements of growing beef cattle 3.0 g/kg in the DM of their diet (McDowell, 2003) [13] of growing beef cattle. All the forages had sufficient Cu values required to meet the requirements of growing beef cattle (10 mg/kg DM; McDowell, 2003) [13] except a few in the highland regions, Low Cu in evaluated grasses may be caused by the high pH (7.5–8.5) in soils (Spears, 1994) [18] of these region

The high acceptability rate for legumes Fig 9 could be associated with low NDF value and high CP content which is responsible for increased intake and increase in milk yield. These means that feeding ruminant livestock with the studied legume feeds would translate to tremendous increase in production. Thus, the results inform that legume species promotes animal performance and should thus be included while feeding to boost the production for sustainable ruminant productivity under ASALs ecosystems

Conclusion

Nutritional quality of forages is key determinant in animal performance and should not be lost while breeding feeds for livestock production. Better quality grass, characterized by lower fiber and high protein content, is potentially promising in improving livestock productivity. Supplementation using legumes is also recommended to enhance animal production potential

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