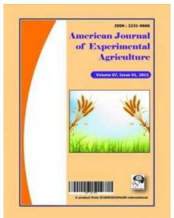

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Performance Evaluation of *Moringa oleifera* and Available Roughages (Maize and Australian Sweet Jumbo) on Feeding Values of Growing BLRI Cattle Breed-1 (BCB-1) Bulls

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Authors' contributions

This work was carried out in collaboration between all authors. Author BKR designed the study, wrote the protocol and wrote the first draft of the manuscript. Author KSH reviewed the experimental design and all drafts of the manuscript. Authors BKR and MKB managed the analyses of the study. All authors identified the plants. Authors BKR and KSH performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

The present experiment was conducted to evaluate intake, digestibility and growth performances of local growing bulls fed Moringa plant fodder or Australian Sweet Jumbo alone keeping Maize silage as control and to scaling up the available roughages. Eighteen BLRI Cattle Breed-1(BCB-1) growing bulls of 103.8±25.5 Kg live weight were randomly allocated to three dietary groups designed in a completely randomized design, having six animals in each group. The three experimental diets were Australian Sweet Jumbo silage and Moringa foliages considered as

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treatments and Maize silage keeping as control. Daily DM intake of bulls fed Moringa foliage was significantly higher (p<0.01) than those fed with Maize or AS Jumbo. A similar trend in CP (p<0.001) and OM (p<0.01) intake was found among the roughages. Compared feeding with AS Jumbo silage, the relative DM intake was increased (p<0.01) by 11.79 and 26.02 per cent, respectively for bulls fed Maize and Moringa foliages. The digestible DM, DCP, DE, ME and MP intake was significantly higher (p<0.001) in bulls fed with Moringa than the bulls fed with other roughages. Digestibility coefficient of nutrients reflected that Moringa foliage had the highest DM, CP, or OM digestibility, and they were significantly (p<0.001) higher than that of Maize or AS Jumbo. However, AS Jumbo fed bulls had a significantly (P<0.01) lower digestibility of DM, OM or CP. Maize had the highest NDF digestibility compared to other two roughages. However, the ADF digestibility of Maize, AS Jumbo and Moringa foliage did not differ significantly (p>0.05). Feeding Moringa foliage had significantly (p<0.05) higher average daily gain of 376 g compared to 289g of Maize or 218 g of AS Jumbo with an average feed conversion efficiency of 8.85, 11.52 and 13.08 respectively. It was concluded that *Moringa oleifera* had higher nutritional significance and less cost of production compared to Maize and Australian Sweet (AS) Jumbo silages.

Keywords: Moringa; Maize; Jumbo; intake; digestibility; feed efficiency; growth and rank.

1. INTRODUCTION

Good quality roughage is being positive response to increase the production and productivity of ruminant animals was developed as one of the most important way for Bangladesh for fulfilling the growing requirements of feed demand. Fibrous feed like crop residue, green grass, and tree foliages are failed to satisfy the farm animal for increasing the productivity. Quality roughage in terms of biomass yield, chemical composition, nutritional value and cost effectiveness plays an important rules on livestock feed. Increasing food-feed competition and cost with an ever increasing demand for safe and high quality beef or dairy products may be minimized to some extent by improving feed efficiencies of animals. Considering the beef production, 55 to 75 % cost was associated with feed cost [1-3]. Cattle fattening or beef enterprise is an important avenue for income generation for subsistence farmers as well as entrepreneurs. Fodder crops may play pivotal role in the agricultural economy of developing countries by providing cheapest source of feed for livestock. However, the shortage of feeds and fodder both in terms of availability and nutritional quality are major concern to the producers and also considered a major constraint to animal productivity [4]. The country requires 49.2 million tons DM of roughage and 24.0 million tons of concentrate quantitively [5] but filling only 56.2% and 20.0%, respectively of their total requirement in a year. Any effort that i) explores quality feeds and fodders ii) generate production technologies for making their biomass available using agro-ecosystem sustainably & economically, and iii) add value addition technologies for production and marketing of cost effective premixed feeds using available biomass may boost milk and meat production in the country. This requires qualitative evaluation of available roughages both in terms of chemical composition and feeding values to animals, and ranking them accordingly based on their yield, production cost, nutritional value and productivity. Moreover, scaling or ranking of available roughages based on their yield, production cost, nutritional value and productivity in the country is not developed yet. Such a ranking tool or scale may support farmers to feeding their animals cost effectively. Considering the above factors the present research work was undertaken to evaluating intake, digestibility and growth performances of growing cattle fed with Moringa plant fodder or Australian Sweet Jumbo keeping Maize silage as control and to rank the available roughages.

2. MATERIALS AND METHODS

2.1 Experimental Location

This experiment was carried out with different types of available green fodders and Moringa foliages at the Cattle Research Farm, Pachutia, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh. Nutritional analysis was done at Animal Nutrition laboratory under the Animal Production Research Division of BLRI, Savar, Dhaka, Bangladesh.

2.2 Fodder Cultivation

The seeds of Australian Sweet Jumbo (*Sorghum bicolor*; "AS Jumbo") and Maize fodder (*Zea mays*; BARI hybrid) were procured from local authorized sources and cultivate in the Patuatia Fodder Research Plot, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh. All the recommended and standard agronomic practices were followed during sowing to harvest period. At the early stage of maturity considering the flowering stage, the Sweet Jumbo was harvested and Maize harvested at the same stage of maturity.

2.3 Silage Making

For silage making, the fodder was chopped into 6-8 cm using a chaf cutter machine and then ensiled in earthen pit. The silos were filled rapidly and pressed properly to remove air for making good anaerobic condition. Each pit was covered with 2 inches thick layer of rice straw and outer surface of the pit was also covered by plastic sheet then plastered with mud to avoid any cracking. The silage pit was not opened for 30 days to follow the fermentation procedure. After fermentation, the plastic sheet was removed to take the silages for feeding, starting withdrawal of silages through the upper layer and working downwards to the lower layers. Per day requirement of silage was taken out for animal feeding. After being taken silage from the pit, the plastic sheet was put back to keep the pit sealed.

2.4 Collection and Processing of Moringa Plants Fodder

Moringa (*Moringa oleifera*) plants fodder was collected from BLRI fodder research plot. The fresh Moringa fodder plants was chopped using a chaff cutter machine, sun dried for 3-4 days and grounded it using a roughage grinder machine. The processed Moringa plants fodder had a leaf to stem ratios of 1.2:1 and acid detergent fiber (ADF) to crude protein (CP) ratios of 1.84:1 on dry matter basis.

2.5 Experimental Design, Animals and Diets

Eighteen BCB-1 growing bulls of 103.8±25.5 Kg live weight and 14-22 months of age were randomly allocated to three dietary groups having six animals in each group. Three dietary groups were AS Jumbo silage and Moringa foliages considered as treatments and Maize silage as control. The experimental animals were housed individually and fed only the roughage diets *ad libitum* for a period of 75 days; first 15 days was given for the adjustment of feed and the rest 60 days was considered for feeding trial. Fresh and clean water was made available in the sheds for whole experimental period. At the onset of feeding trial, animals were dewormed properly with Endex ® (Levamesol BP 600 mg per bolus) at a rate of 20 mg per kg live weight.

2.6 Body Weight Measurement

After feed adjustment, all the experimental bulls were weighed initially just after arrival in the experimental shed for feeding trial and 10 days thereafter by a platform digital balance with a weighing range 0.00 kg to 1000 kg and a minimum graduation of ± 0.1 kg. Each bull was weighed before morning feeding. The total live weight gain was calculated by subtracting the initial weight from the final weight taken at the experimental period and the daily weight gain was calculated by dividing the total weight gain by the number of experimental days.

2.7 Feed Intake Estimation

The daily feed intake was measured by subtracting the amount of refusals from the amount of feed offered in the previous day. During feeding trial, the total intakes i.e., the actual intake of roughages fed by the animals were recorded on daily basis.

2.8 Digestibility Trial

During 50 days of feeding trial, a digestibility trial was conducted and faeces ware collected separately for seven days. Records were kept on amount of feed offered, residue left and faeces excreted. During the collection period, composite samples of feed, residue and faeces of individual animal were stored at -20℃.

2.9 Chemical Analysis

Samples of feeds, residue left and faces were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF) and acid detergent fiber (ADF). DM was determined by oven drying samples at 105℃ for overnight. Ash determination was done at 550℃ for 8 h, total nitrogen (N) by Kjeldahl procedure and CP calculated from N content (CP = N × 6.25) according to the official methods of AOAC [6]. NDF and ADF were determined by the procedure proposed by Goering and Van Soest [7]. Apparent digestibility coefficient for DM was calculated from dietary intake of constituent and amount recovered in faeces. The gross energy of the diets were determined using Bomb Calorimeter (Model IKA).

2.10 Statistical Analysis

The response to dietary treatments on intake, digestibility, nutritional quality and growth rate were compared statistically in an ANOVA of a Completely Randomized Design (CRD) using GLM Procedures of SPSS, 11.1 for Windows (SPSS) [8] computer software packages. The least significant difference (LSD) test was used when the difference between treatments means was significant.

3. RESULTS

3.1 Nutrient Composition of Experimental Diets

Chemical composition of the roughages is shown in Table 1. Among the three different roughages Moringa foliage had a higher level of crude protein (CP 18.62%) compared to others (varied from 9.20% to 9.47%), and 34.27% ADF, 55.27% NDF and 7.87% ash. The ADF & NDF content of Maize and AS Jumbo was 37.86% & 44.99% and 66.40% & 64.70%, respectively. Organic matter, as a percentage of DM, was the highest for Maize, followed by AS Jumbo and Moringa foliage. The gross energy content was relatively higher (17.7 MJ/Kg DM) in Moringa foliage followed by Maize (17.6 MJ/Kg DM) and AS Jumbo (17.0 MJ/Kg DM) silage (Table 1).

3.2 Nutrient Intake

DM, OM, CP, fibre components (NDF and ADF), DDM, DCP, DE, ME and MP intakes for the different roughage diets are shown in Table 2. Maize, AS Jumbo and Moringa foliage had per head daily DM intake of 2.75 Kg, 2.46 Kg & 3.10 Kg, respectively, and their intake percent live weight was 2.51, 2.25 and 2.81%, respectively. Daily DM intake of bulls fed Moringa foliage was significantly higher ($p<0.01$) than those fed with Maize or AS Jumbo. A similar trend in CP ($p<0.001$) and OM ($p<0.01$) intake was found among the roughages. The OM ($p<0.01$) & CP ($p<0.001$) intake were significantly higher in bulls fed Moringa foliages than bulls those fed other diets. However, the intake of both NDF and ADF did not vary significantly ($p>0.05$) among the roughage diets. The relative DM intake was increased ($p<0.01$) by 12.73 per cent and decreased by 10.55 per cent, respectively for bulls fed Moringa foliages and AS Jumbo compared in bulls fed with maize silage. On the other hand, to compare feeding with AS Jumbo silage, the relative DM intake was increased ($p<0.01$) by 11.79 and 26.02 per cent, respectively for bulls fed Maize and Moringa foliages. Similarly, the relative CP intake was increased by 130.7 per cent and decreased by 7.69 per cent, respectively. The digestible DM or DCP intake was higher ($p<0.001$) in bulls fed with Moringa than the bulls fed with other roughages. Similarly, the digestible energy or metabolizable energy or metabolizable protein intake (34.57 MJ/day, 28.35 MJ/day and 154.3 g/day) of bulls fed Moringa was significantly ($p<0.001$) higher than bulls those fed with Maize (28.73 MJ/day, 23.56 MJ/day and 128.2 g/day) or AS Jumbo (22.55 MJ/day, 18.48 MJ/day and 100.7 g/day).

3.3 Nutrient Digestibility

The apparent digestibility of nutrients by bulls fed different roughages has been presented in Table 3. The results on digestibility coefficient of nutrients reflected that Moringa foliage had the highest DM (62.67%), CP (74.38%) or OM (62.84%) digestibility, and they were significantly ($p<0.001$) higher than that of Maize or AS Jumbo. Among the dietary groups AS Jumbo fed bulls had a significantly ($P<0.01$) lower digestibility of DM, OM or CP. The NDF digestibility of Maize, AS Jumbo and Moringa foliage were 67.67, 58.27 and 64.38 per cent, respectively and Maize had the highest NDF digestibility, they were significantly ($p<0.01$) higher than that of Moringa and AS Jumbo. However, the ADF digestibility of Maize, AS Jumbo and Moringa foliage did not differ significantly ($p>0.05$). Balwani et al. (1969) reported that Dry matter, organic matter and crude protein digestibility of maize silage was significantly ($p<0.05$) higher than sorghum silages. The values for dry matter digestibility, organic matter digestibility and crude protein digestibility of maize and forage type sorghum were 68% vs 55%; 69% vs 56%; and 56% vs 55%, respectively.

3.4 Live Weight Gain and FCR

Both the initial and final live weight in bulls did not vary significantly ($p>0.05$) among the dietary groups. However, feeding Moringa foliage had significantly ($p<0.05$) higher average daily gain of 376 g compared to 289g of Maize or 218 g of

AS Jumbo and their average feed conversion efficiency of 8.85 of Moringa foliage, 11.52 of Maize and 13.08 of AS Jumbo, respectively. Considering beef production performances, the three different roughages may be ranked as Moringa> Maize>AS Jumbo based on their coefficient of nutritional response to growth of 1.3, 1.0 and 0.88, respectively. It was not only the higher DM, CP and ME intake and greater digestibility of DM, OM, and CP but also the higher anti-oxidative properties could be the reasons for exhibiting higher growth rate and better FCR of bulls fed Moringa foliage than bulls those fed other roughages.

3.5 Biomass Yield

The biomass yield and production cost of different fodders and silages are presented in Table 5. The annual fresh biomass yield per hectare land of Moringa, Maize and AS Jumbo were 228, 130 and 100 metric tons (Table 5), respectively under the standard agronomic management condition. A single cultivation of Moringa, the number of harvesting per year of was considered 6 times, similarly, a single cultivation of AS Jumbo harvested 3 times in a year. However, maize was cultivated separately 3 times in a year.

Table 1. Chemical composition of experimental diets

Nutrients	Experimental diets		
	Maize silage	AS Jumbo silage	Moringa foliage
DM, % fresh	19.18	23.42	85.52
	% DM basis		
OM	94.31	92.72	92.13
CP	9.47	9.20	18.62
ADF	37.86	44.99	34.27
NDF	66.40	64.70	55.27
Ash	5.71	7.28	7.87
GE (kcal/Kg DM)	4203.7	4060.4	4227.6

Table 2. Nutritional responses of different roughages fed experimental animals

Parameters	Experimental diets			SED	Level of sig.
	Maize	AS Jumbo	Moringa foliage		
DM intake (kg/d)	2.75^{b}	2.46^{b}	3.10^{a}	0.10	**
DM intake (kg; % LW)	2.51^{ab}	2.25^{b}	2.81^{a}	0.12	*
OM intake (kg/d)	2.58^{ab}	2.28^{b}	2.87^{a}	0.09	**
CP intake (kg/d)	0.26^{b}	0.24^{b}	0.60^{a}	0.01	***
ADF intake (kg/d)	0.93	0.98	0.97	0.05	NS
NDF intake (kg/d)	1.75	1.48	1.69	0.06	NS
DDMI (Kg/d)	1.63^{b}	1.32^{c}	1.95^{a}	0.06	***
DCPI (Kg/d)	0.16^{b}	0.14^{b}	0.45^{a}	0.01	***
DE intake (MJ/d)	28.73^{b}	22.55^{c}	34.57^{a}	1.07	***
ME intake (MJ/d)	23.56^{b}	18.48^{c}	28.35^{a}	0.87	***
MP intake (g/d)	128.2^{b}	100.7^{c}	154.3^{a}	4.77	***

*Means within the same row bearing different superscripts differ significantly; NS= Non significant, *= (p<0.05), **= (p<0.01), ***= (p<0.001)*

Table 3. Apparent digestibility of nutrients by bulls fed different roughages

Parameters	Experimental diets			SED	Level of sig.
	Maize	AS Jumbo	Moringa foliage		
DM	59.63^{b}	53.83^{c}	62.67^{a}	0.82	***
OM	61.56^{a}	55.83^{b}	62.84^{a}	0.81	***
CP	60.11^{a}	58.74^{a}	74.38^{b}	0.83	***
ADF	54.33	53.52	52.08	0.99	NS
NDF	67.67^{a}	58.27^{b}	64.38^{c}	0.71	**

*Means within the same row bearing different superscripts differ significantly; NS= Non significant, **= (p<0.01), ***= (p<0.001)*

Table 4. Growth responses and FCR of bulls fed different roughages

Parameters	Experimental diets			SED	Level of sig.
	Maize	AS Jumbo	Moringa foliage		
Initial LW (kg)	104.0	103.6	103.8	5.49	NS
Final LW (kg)	121.4	116.7	126.4	5.43	NS
Ave. daily gain, g	289^{ab}	218^{b}	376^{a}	40.6	*
FCR	11.52	13.08	8.85	1.70	NS
Nutritional coefficient					
FCR response	1.00	0.88	1.30	-	-

*Means within the same row bearing different superscripts differ significantly; NS= Non significant (p>0.05), *= (p<0.01)*

3.6 Cost of Feeding

The analysis of cost of cultivation of fodders involved various components of costs such as variable cost and fixed cost. Under the variable cost the following components such as cost of seed/cutting, land preparation, sowing cost, organic and inorganic fertilizer, weeding, irrigation harvesting, processing etc. were considered. Variable costs vary directly with the production. For the fixed cost component, only the rental value of land was considered under this experiment, the depreciation of implements, interest on fixed capital and land revenue etc. were ignored. Annual production cost of different fodders is shown in Table 5. It shows that the average product cost (fresh biomass; variable + fixed cost) per hectare per year required for Maize, AS Jumbo and Moringa were US$ 1,854.87, US$ 1,582.9 and US$ 4,220.38, respectively. The product cost for Kg fresh biomass of Maize, AS Jumbo and Moringa were US$ 0.014, US$ 0.016 and US$ 0.018, respectively and the cost for Kg silages of Maize and AS Jumbo were US$ 0.017 and US$ 0.019, respectively. The cost involvement for kg DM yield of Maize, AS Jumbo and Moringa foliage were US$ 0.092, US$ 0.083 and US$ 0.093 respectively (Table 5). The higher cultivation cost of Maize is due to use higher amount of seeds, fertilizer and increased cost for separate land preparation. The cost involvement of Kg LWG of bulls fed different roughage diets is presented in Table 6. It shows that the total roughage cost including refusal losses of kg live weight gain were US$ 1.22, US$ 1.32 and US$ 1.00, respectively for bulls fed Maize, AS Jumbo and Moringa foliage. Considering diet, refusal, management cost and time or days required for Kg LWG, the Moringa foliage fed animals required lower feed cost (US$ 1.30) followed by Maize (US$ 1.53) and AS Jumbo (US$1.65). Considering the cost of beef production, the roughages may be ranked as Moringa>Maize>AS Jumbo.

The relationship among the average daily gain (kg), Feed Conversion Ratio (FCR) & cost of per kg live weight gain (US$) with different roughages shown in Fig. 1. It was observed that, Moringa foliage was superior on the basis of production performance (R^2 =1) and cost of live weight gain (R^2 =0.4) to Maize and AS Jumbo silage. It was also revealed that Moringa foliage is the most nutrient rich fodder for profitable livestock production in Bangladesh.

4. DISCUSSION

Some of the key factors in term of quality and quantity that is highlighted the changing of dynamics of livestock sectors between the cattle producers and researchers. One of the most important strategies is to develop profitable beef cattle entrep [9] reneur [9] that reduces the feeding cost and more efficient use of different varieties of forages [10-12]. In this experiment, for ranking the different roughages with Moringa plant fodder on the basis of nutritive value, intake, digestibility, growth performance and cost of production. It was found that Nutritive value of Moringa foliage comparatively higher than that of Maize silage than the AS Jumbo silage. Protein is an exclusive nutrient in feed that is rich in the Moringa foliage which was 18.62 % in the experimental diet. It was more than double compare to other roughages. A similar finding was observed through sultana et al. [13]; Huque et al. [14] and Bashar et al. [15]. In comparison with silages, the present results with relatively lower levels of CP in Jumbo silage and higher level of CP in maize silage is agreement with statements of Harris et al. [16]; Adewakun et al. [17] and also reported that Jumbo silage (Sorghum) had more structural polysaccharide than in maize silage.

Table 5. Biomass yield and production cost of fodders and silages (US$/hectare/year)

Inputs	Maize	A.S. Jumbo	Moringa foliage
Seed/cutting	95.6	56.2	750.0
Land preparation (fuel for plough, disc, harrow etc.)	191.2	63.7	18.7
Sowing cost	11.3	3.8	65.0
Fertilizer (DAP, urea)	202.5	127.5	56.4
Weeding	78.8	131.2	1,875.0
Cow dung	75.0	50.0	33.8
Irrigation or water (electricity cost)	125.0	125.0	-
Harvesting (labor, fuel for transportation)	475.5	425.4	358.9
Silage pre./processing of feed (pit, polyethylene, filling, fuel for chopping, labor etc.)	447.9	373.7	312.5
Rent for land	562.5	562.5	562.5
Miscellaneous	37.5	37.5	187.5
Total production cost (Fresh, US$/Y/h)	1854.87	1582.9	4220.38
Total cost (silage, US$/Y)	2302.77	1956.65	-
Product per hectare (fresh; tons/year)	130	100.00	228
Product per hectare (DM; tons/year)	24.93	23.42	45.0
Product cost (fresh, US$/kg)	0.014	0.016	0.018
Product cost (silage, US$/kg)	0.017	0.019	-
Cost (US$/Kg silage DM)	0.092	0.083	0.093

Table 6. Cost (US$) involvement of Kg, LWG of bulls fed different roughage diets

Roughages	FCR	Cost/Kg.DM	Refusal cost	Increase of cost considering refusal (US$)	Cost roughage diet (US$/Kg LWG)	Days for Kg LWG	Management & others	Cost/Kg Gain
Maize	11.52	0.092	0.014	0.106	1.22	3.5	0.305	1.53
A. S. Jumbo	13.08	0.083	0.017	0.101	1.32	4.6	0.33	1.65
Moringa foliage	8.85	0.093	0.019	0.113	1.00	2.7	0.301	1.30

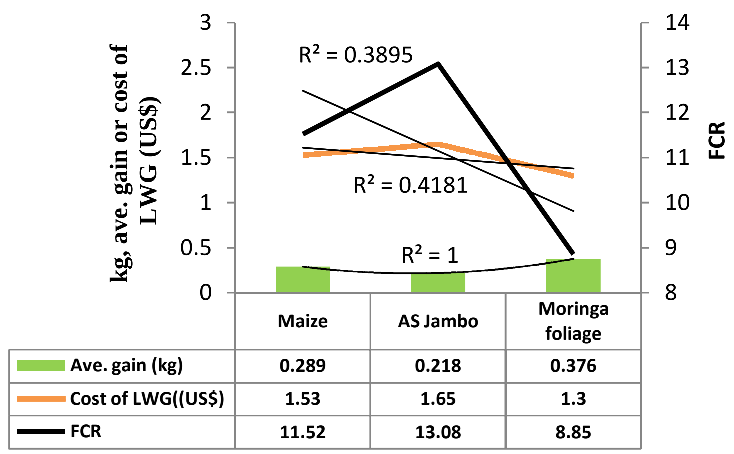

Fig. 1. Feeding effect on FCR, ave. daily gain (kg) and cost of per kg live weight gain (US$)

The result also shown that the Moringa foliage as a protein supplement with low quality diets improved DM intake and digestibility of the diets and significantly ($p<0.05$) higher live weight gain (376 g/day) than that of other two roughages (218 g/day for AS Jumbo or 289 g/day for Maize silage, respectively). Sultana et al. [13] reveal that, Moringa foliage is 3.29 time more efficient than the Napier diet for converting to live weight gain of growing male goats. Adding *Moringa oleifear* leaves with green stem to fodder that in increased cattle's daily weight gain upto 32% [18] and improved nutritional status [19-22]. It also stated that using medicinal plants and probiotics are positive effect on growth performance and meat quality of ruminant animals [23-24]. The present findings are in agreement with Keady and Gordon, [25] who reported that feeding maize silage as the sole forage reduced feed costs by 37 penny/kg carcass gain ($P<0.001$) than bulls those fed other grass silage.

5. CONCLUSION

Considering the nutritional quality of roughages and cost of beef production, the roughages may be ranked as Moringa foliage> Maize silage>AS Jumbo silage. However, farmers may use this roughage scale in formulating cost effective diets for making more profit of cattle production. Moreover, these data will lead further development of feeding models for beef production in the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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