Original Research Article
Effects of finishing strategies on the performance and profitability of Boran crossbred cattle

ABSTRACT

A study was conducted to determine the effects of finishing strategies on the performance and economic viability of finishing Boran crossbred cattle. Fifty-four (54) bulls were allocated randomly in three feeding practices and three slaughter periods in a 3*3 factorial experiment. The feeding practices comprised ~~of~~ grazing alone (P1) as a control, grazing with concentrate supplementation (P2), and feedlot finishing (P3). Three bulls from each practice were slaughtered at 45 days (S1), 60 days (S2), and 75 days (S3) of the finishing period. Data on feed intake, growth performance, slaughter, and carcass characteristics were recorded. The average energy and protein intake (ME, MJ/d, CP, g/d) by bulls on P3 (97, 1056) and P2 (95, 1090) were higher (P<0.05) than those on P1 (42, 499). The bulls finished on P3 and P2 had the highest average daily gain (1.08 and 0.93 Kg/d), final live weight (272.83 and 262.06 Kg), and hot carcass weight (149.62 and 140.35 Kg) compared to those on P1 (0.43 Kg/d, 231.50 Kg and 121.01Kg, respectively). A Significant interaction between finishing practice and the slaughter period was detected for dry matter intake, weight gain, final weight, and variable costs. Indicating that P2 and P3 bulls tended to have greater DMI, resulting in higher weight gain, final weight, and total variable costs than bulls on P1. The profit margin (TZS per bull) associated with bulls on P2 was found to be twice higher (188,296) than that of bulls finished on P1 (82,867). In conclusion, Boran crossbred bulls improved growth performance and carcass yield after 75 days of feedlot and grazing coupled with concentrate supplementation practices. Stakeholders are advised to opt for grazing with a concentrate supplementation strategy for enhanced productivity. Further studies are proposed to assess the quality of beef produced and evaluate finishing strategies for other improved beef breeds in the country.

Keywords: Grazing only, concentrate supplementation, feedlot, slaughter time, cost-benefit

1. INTRODUCTION

The increases in the global population and economic prosperity have resulted in escalating demand for prime meat [1]. This is similarly experienced in Tanzania and exacerbated by the influx of expatriates, tourists, and emerging middle-income clusters [2-3]. Nevertheless, there is a substantial number of cattle in Tanzania, which is ranked third in cattle population in Africa. To date, the cattle herd size is approximately 37.9 million, of which 99.4% are indigenous breeds [4], which serve as the principal source of meat for approximately 98% of the growing human population [5] in the country. Despite the significant importance of the cattle resource, it is entirely managed under a low-input production system, characterized by limited availability and poor feed resources. Grazing has remained a dominant practice among agro-pastoralists and pastoralists [6]. It is characterized by low nutrients of varying nutritional content and often insufficient to meet the important nutrient requirements for beef cattle maintenance and production [7-8]. Furthermore, the grazing practice is currently constrained by several challenges, including limited land to support cattle and wild animals, increased land degradation, and animal health issues. Although grazing practice offers various merits, including cost-effectiveness and nutrient cycling, other times, grazing alone cannot supply adequate amounts and quality pastures to support animal requirements. In meeting these challenges, it could be imperative to shift away from total dependence on pasture and seasonality of the year by embracing either feedlot or grazing with concentrate supplementation practices in finishing cattle. Finishing practices based on production targets, product quality and quantity, and market requirements, positively influences animal growth, finishing time, and production economics [9].

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For an increased yield of high-quality beef, efforts are needed to ensure feed availability for supplyingto supply adequate nutrients to promote growth and shorten slaughter time. Finishing cattle in feedlot or combining grazing with concentrate supplementation are practices that could enhance the performance of grazing animals in a short time. Studies on finishing TSHZ steers on grazing with concentrate supplementation showed significantly improved weight gains of 1000 g/d compared with 600 g/d observed on grazing alone [10]. A more remarkable improvement in weight gains was reported on TSHZ steers, whereby there was increased carcass weight from 90 kg for grazing alone to 154 kg after finishing on the feedlot [11]. Similarly, a study conducted in Uganda revealed that crossbred of Ankole*Friesian finished on a feedlot exhibited the highest growth rate (930 g/d) and carcass weight (138.1 kg), while that of Ankole*Boran demonstrated comparatively lower performance (750g/d and 134.7 kg, respectively) [7]. These findings underscore the potential benefits of crossbreeding Boran with other breeds to enhance both the quantity and quality of beef production, exploiting the advantages of larger body size and rapid growth rates. However, there remains a scarcity of comprehensive data regarding the productivity and appropriate slaughter period of improved breeds when subjected to both feedlots finishing and grazing with concentrate supplementation. Notwithstanding, finishing on feedlot and grazing with supplementation of TSHZ and Boran cattle is rapidly growing. However, though performance indices, such as growth rates, slaughter weight, carcass weight, and profitability, remain unclear to stakeholders and potential investors. It is hypothesized that finishing Boran crossbred cattle using appropriate practice and slaughter time could improve beef cattle productivity and meet the demand for quality beef in niche markets. The aim of the study, therefore was to establish strategic conditions for finishing Boran crossbreds for improved, was to establish strategic conditions for improving the finishing Boran crossbreds to enhance the productivity of prime beef.

2. MATERIALS AND METHODS

2.1 Description of the study area

The study was carried out in Kidago farm, which is situated in the Mkuyuni division within the Morogoro Rural district in the eastern part of Tanzania, approximately 33 km away from Morogoro town along Dar es Salaam to Morogoro Road. The coordinates of the area are 6° 46' 0" S and 37° 53' 59" E, with an elevation of 502 m above sea level. The average temperature ranges from 21.9 to 27.3 °C, while the mean annual rainfall stands at 972 mm. The dominant vegetation of the area includes *Bracharia sp*, *Chloris gayana*, *Urochloa, Panicum, Eragrostis, Cynodon* grass species, *Acacia polyacantha*, and *Acacia tortilis* woody species.

2.2 Experimental design and treatments

Fifty-four (54) bulls were randomly allocated in a 3*3 factorial arrangement in a completely randomized design experiment, with two independent variables, namely; finishing practices and slaughter periods, each consisting of six (6) replications. The finishing practices included grazing alone (P1), grazing with concentrate supplementation (P2) and feedlot (P3), each having 18 animals. The slaughter periods involved three (3) animals from each practice slaughtered at 45 (S1), 60 (S2) and 75 (S3) days of the finishing period.

2.3 Description of the experimental feeds

A single concentrate diet was formulated to meet the animal nutrient requirements [12] of 12 MJ ME and 14% CP, as presented in Table 1. All the dietary ingredients were procured from Morogoro Municipal's local agricultural input suppliers. Samples of natural pastures were collected from the grazing lands of Kidago Farm at different stages of the experiment for chemical analysis. Samples of hay were collected from the on-farm conserved hay, which was made using *Chloris gayana* established at the farm.

Table 1. Physical composition (% as fed) of the experimental diet (ED) and price values in Tanzania shillings (*1 TZS ≈ USD 3.876 x 10^{-4}*)

Ingredients	Inclusion (%)	Price (TZS/kg)
Hominy feed	36	500
Cassava meal	18	700
Rice polishing	6	200
Sunflower Seed Cake	38	380
Mineral premix	1.5	2000
Common salt	0.5	250
Total	**100**	
Price of ED (TZS/kg DM)		468.2
Calculated composition		
Crude protein (CP, %)	14	
Metabolisable energy (ME, MJ//kg DM)	12	

2. 4 Source and management of the experimental animals

The 54 bulls were crossbred of Boran bulls with Sahiwal cows found at Kidago Farm. They were aged between 2 and 3 years, determined by examining their dentition, and weighed approximately 205 ± 1.89 kg. The selected bulls were tagged with numbered plastic ear tags for identification and allowed to graze on natural pastures for fifteen days before the initiation of the experiment for backgrounding. ~~Thereafter~~After that, the initial body weight of the animals was estimated over three consecutive days~~,~~ using a measuring band (RONDO®, a combined measuring tape for cattle and pigs). This was done by measuring the chest circumference of the animal behind the hump of the elbow joint, whereby the live weight of the animal in kg was directly noted on the reverse side of the measuring tape. This procedure was used for all records of the body weights of the animals. Thereafter, all the bulls were treated and controlled for endo-parasites by dosing each subcutaneously with 1% ivermectin. For controlling ticks and tsetse flies, the bulls were sprayed with an acaricide (TIKTIK® AMITRAZ 12.5% E.C, batch No: FBTK.1001) at the beginning of the experiment and once weekly during the experimental period.

The animals were allotted randomly to the experimental treatments and housed in a simple cattle finishing structure constructed at Kidago farm using poles~~,~~ roofed with iron sheets to protect them from rain and direct sunlight. The structure consisted of thirty-six (36) pens, each measuring 1 m x 2.5 m and equipped with feeding and watering troughs. A preliminary period of 10 days was allowed for the animals to familiarize themselves with the feeds and experimental settings. Animals on Practice P1 grazed on a closed paddock for 10 hours a day, from 0800 h to 1800 h. During night hours, they were kept in separate night sheds without feeding. Animals on Practice P2 were grazed from 0800 h to 1600 h and thereafter were individually penned and given free access to the formulated concentrate diet. Animals on Practice P3 were individually penned and fed *ad libitum* (10-15 % refusal) on both the formulated concentrate diet and hay, twice daily, at 0800 h and 1600 h. All the experimental animals had access to clean and fresh drinking water~~,~~ sourced from a borehole at the farm. The feed offered to each animal on practices P2 and P3 was weighed using a spring balance. The refusals were collected separately and individually weighed using a digital weighing scale. The live weight of each animal was estimated weekly~~,~~ in the morning before feeding using the measuring band. In the last three days before attainment of the specific slaughter period, that is, 45, 60, and 75 days of the finishing periods, three consecutive body measurements of each animal were taken for the estimation of the final body weight.

2.5 Slaughter procedure and carcass measurements

At 45, 60, and 75 days of the finishing period, 27 animals, three from each feeding practice in each slaughter period, were randomly sampled for slaughter. The selected bulls were trucked to the slaughter facility at Mgolole Agro-processing Co. Ltd, which is located 30 km West of Kidago farm. Upon arrival at the slaughter premise, the animals were subjected to a 24-hour fasting period with free access to drinking water. Prior to slaughter, the slaughter weight (SWT) of each animal was estimated using the measuring band. A captive bolt pistol stunner was used to render the animal unconscious for humane slaughtering. Thereafter, the neck was severed at the jugular and carotid vessels using a sharp knife operated by a trained and authorized Muslim, following Halal procedures [13]. The animal's body was suspended on an overhead rail system using a hoisting chain for bleeding. This was followed by dressing procedures that included flaying, evisceration, and removal of the head at the atlanto-occipital joint and fore and hind feet at the carpus-metacarpal and tarsus-metatarsal joints, respectively. The gastrointestinal tract (GIT) was removed immediately after slaughter and weighed to obtain the weight of full GIT in kilogram. The GIT content was then emptied, and the GIT was weighed to obtain empty GIT, whereby the difference between the full GIT and empty GIT gave the weight of gut contents. The dressed carcasses were longitudinally split into two symmetrical halves along the middle plane of the spinal column using a handsaw. The weight of the two halves was considered as hot carcass weight (HWC). The produced carcasses were sold at the local market, and all sales were recorded for economic assessments of the finishing strategies.

2.6 Laboratory analysis

Laboratory analysis was conducted on the samples of forages, dietary ingredients and the formulated diet. The analyses involved the estimation of the contents of dry matter (DM), ash, crude protein (CP), ether extract (EE), crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF) and metabolizable energy (ME) using near-infrared reflectance spectrophotometer (NIRSystems 5000 Firmware Version 156). The instrument was calibrated for the formulated concentrate diet (tmrgpfe.eqa) and the forage (mhaygpfe.eqa) following the procedures described by [14] and [15], respectively.

2.7 Parameters derived

2.7.1 Feed dry matter intake

The daily feed dry matter intake (DMI) by individual animals on the grazing alone (P1) was estimated using the equation developed by [16] as follows;

$$DMI\ (kg/day) = (1.185+0.00454BW-0.0000026BW^2+0.315ADG)^2 \quad \ldots\ldots(1)$$

Where, DMI=Forage dry matter intake, BW = Live body weight, and ADG = Average daily live weight gain.

The forage DMI for animals on forage and concentrate supplementation (P2) was estimated using the equation developed by [17] as follows;

$$DMI\ (kg/d) = -1.912 + 0.900 \times SI + 0.094 \times BW^{0.75} + 1.070 \times ADG - 1.395 \times ADG^2 \quad \ldots\ldots(2)$$

Where, SI = Intake of supplement diet, BW= Body Weight, and ADG = Average Daily Weight.

The feed intake by animals in Practice P3 was obtained by measuring and recording the daily intake of hay and concentrate. The measured and recorded concentrate diet supplemented on Practice P2 plus forage estimated in equation 2 gave the feed intake by animals on Practice P2.

2.7.2 Body weight gain and feed conversion ratio

The average daily body weight gain (ADG) was obtained as the difference between the average initial weight and final weight, divided by the number of days within the finishing period. The average feed conversion ratio (FCR) by the animals on practices P1, P2, and P3 was determined by dividing the daily DMI by ADG of each group.

2.7.3 Slaughter characteristics

The EBW was derived from the slaughter body weight deducting the gut content. The EBW is calculated as EBW = SBW - GIT contents……(3)

where SBW = Slaughter body weight and GIT content= gastrointestinal contents weight (stomach and intestines contents). The dressing percent (DP) was computed as the proportion of live weight left as carcass after slaughter. It was estimated as follows: DP = (HCW x 100) /SBW……..(4)
where HWC= Hot carcass weight and SBW = Slaughter body weight

2.8 Assessment of the economics of finishing cattle

The concept of gross margin (GM) was used to assess the economics of finishing bulls under various practices and slaughter periods by determining the gross margins, by subtracting the total variable costs (TVC) from the total revenue (TR). The TR was generated from the sale of the carcasses by multiplying the carcass weight of each slaughtered animal by the retail market price of 9,000 TZS a kg of meat. The TVC considered animals, feeds, veterinary drugs, water, transportation of feeds and animals, labour wages, and slaughter costs. The fixed costs included the depreciation of the finishing stall. The purchasing cost of the bulls was calculated by multiplying the initial weight of each animal by the market price of 3,500 TZS a kg of live weight at the beginning of the experiment. The price of each ingredient used to formulate the diet was added to determine the price per kilogram of the experimental diet. The feed cost per animal was calculated by multiplying the average cost of one kg (Table 1) of the diet with the total feed intake. The medication costs incurred encompassed *Oxytetracycline*, Penstrep, Ivermectin 1% and TIKTIK® used and were totaled to determine the veterinary costs. The water costs were determined by aggregating the costs incurred for connecting water from the farm's main water source to the finishing stall, which was derived per animal per finishing period. The labour cost was 3,350 TZS per person per day (10 hours per day) for each hired herdsman and attendant.
The straight-line depreciation method was used to determine the fixed costs. The method is presented by the formula: Annual depreciation cost (ADC) = (Cost of asset- Salvage value)/ Useful life…….. (5)
Where Cost of asset refers to the expenses paid to acquire the asset, salvage value is the expected market value of the asset at the end of its useful life, and useful life is the number of years the asset is expected to be used in business. The depreciation cost was estimated at 10,453,500 TZS, the cost incurred in constructing the finishing structures accommodating 36 cattle. The salvage value was assumed as 10% of the cost of constructing the structure and 10 years of useful life. The salvage value divided by the number of animals gave the depreciation cost per animal per finishing period.

The cost of producing one kg of beef for an animal was calculated by adding up all the fixed and variable costs of the respective animal. Thereafter, the average cost of producing 1 kg of meat was calculated by dividing the total expenditure during the experiment by the weight of the carcass produced by the animal. The accrued profit per kilogram of meat produced was calculated by deducting the average cost of producing that meat from the selling price of meat. The profit per carcass was calculated by multiplying the profit earned per kg by the amount of meat produced by the animal. The daily profit per finishing period was obtained by dividing the profit per animal carcass by the appropriate finishing period.

2.9 Statistical Analysis

The General Linear Model (GLM) procedure of SAS [18] was used to statistically analyze the effects of finishing practices, slaughter periods, and their interactions. Finishing practices and slaughter periods were considered as fixed effects and each animal was considered the experimental unit for all the parameters assessed. Initial body weight was included in the model as a covariate. Tukey's pairwise comparison procedure was applied to assess the mean differences between finishing practices, slaughter periods, and their interaction effects, whereby the differences were considered significant at ($P < 0.05$).

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3. RESULTS

3.1 Chemical composition of the experimental feeds

The values of chemical composition and energy contents of the feed ingredients, formulated experimental diet, natural pasture, and hay are presented in Table 2. Among the ingredients used in compounding the experimental diet (ED), sunflower seed cake (SSC) had the highest crude protein (CP) content, while cassava meal (CM) had the lowest value. The formulated diet (ED) had a relatively higher CP content than the estimated value during its formulation (Table 1). The highest value of ether extract (EE) was found in SSC, while the lowest value was observed in CM. Natural pasture (NP) and hay had comparable values of CP and ether extract (EE). The crude fiber (CF) content of the feed ingredients was highest in SSC and lowest in hominy feed (HF) and CM. The contents of neutral detergent fiber (NDF) and acid detergent fiber (ADF) of NP and hay were higher compared to that of the experimental diet. The metabolisable energy (ME) content varied among the feed ingredients, with CM and HF having relatively higher values closer to the ED, which had the highest value.

Table 2. Chemical composition (% DM) and metabolisable energy (ME, MJ/kg DM) contents of the feed ingredients, formulated diet and forages

			Chemical composition					ME
Experimental feeds	**DM**	**CP**	**EE**	**Ash**	**CF**	**ADF**	**NDF**	
HF	94.6	8.5	9	5.4	3.5	NA	NA	12.53
CM	87.3	5.2	3.5	1.5	3.6	NA	NA	13.51
RP	90.3	9.7	11.1	8.2	15.9	NA	NA	8.55
SSC	94.2	23.4	13	5.7	21.8	NA	NA	10.06
ED	92.1	14.7	5.8	7.7	12.4	22.2	37	13.53
NP	90	10	1.3	5.2	40.6	36.9	60.2	8.43
Hay	89.9	9	1.3	4.9	40.5	37.7	61.1	8.35

DM = dry matter; CP = crude protein; EE = ether extract; CF= crude fibre; ADF = acid detergent fibre; NDF = neutral detergent fibre;
HF= hominy feed; CM= cassava meal; RP= rice polishing; SSC= sunflower seed cake; ED = experimental diet; NP = natural pasture NA = Not analysed

3.2 Feed intake and growth performance

Lsmeans of the feed intake and growth performance of the finished bulls are illustrated in Table 3. Bulls finished on grazing and concentrate supplementation (P2) had higher (P<0.05) mean values of forage and total dry matter intake (DMI) compared to their counterparts. The bulls on the feedlot (P3) had the lowest mean value of forage DMI, while the grazing bulls showed lowest the total DMI compared with their counterparts. The bulls on P2 and P3 had similar (P>0.05) intake values of protein (CP) and metabolisable energy (ME), while those on grazing alone (P1) had the lowest (P<0.05) values. Bulls slaughtered on the 75th day (S3) exhibited the highest (*P*<0.05) concentrate, forage and total DMI, giving the group to have also highest nutrients (CP and ME) intakes compared to those slaughtered on the 60th (S2) and 45th (S1) days. There were significant interaction effects (*P*<0.05) between the finishing practices and slaughter periods on the DMI of forage and concentrate (Figure 1a and b). Bulls on feedlot (P3) consistently maintained lower mean forage DMI throughout the slaughter periods. Bulls on grazing alone (P1) had slightly higher mean forage DMI than those on grazing plus concentrate supplementation (P2) at the early stages of finishing (S1) and maintained at that level of intake up to the 75th day of finishing. On the other hand, bulls on P2 increase the forage intake sharply and overtake those on P1 as finishing progressed to 60th (S2) and 75th (S3) days of slaughter. The mean value of concentrate intake by bulls on P2 at slaughter period S1 was slightly higher

than by those on P3. As the finishing period progresses to slaughter periods S2 and S3, the intake of concentrate by bulls on P2 decreases sharply, while that of P3 increases.

Table 3. Least square means ± SEM for intake and growth performance of Boran crossbred bulls used in the experiment

Parameter	Finishing Practices					Slaughter periods					FP*SP
	P1	P2	P3	SEM	*P*-value	S1	S2	S3	SEM	*P*-value	*P*-value
Number of observations (n)	18	18	18			9	9	9			
DMI (kg/d)											
Concentrate	NA	2.93	6.40			4.29^{b}	4.59^{b}	5.11^{a}	0.08	0.0003	0.0131
Forage	4.99^{b}	6.6^{a}	1.28^{c}	0.04	<0.0001	4.07^{c}	4.27^{b}	4.54^{a}	0.04	0.0001	0.0002
Total DMI	4.99^{c}	9.53^{a}	7.68^{b}	0.08	<0.0001	8.36^{b}	8.86^{b}	9.65^{a}	0.09	0.0001	0.6067
ME intake (MJ/d)	42.07^{b}	95.25^{a}	97.27^{a}	0.72	<0.0001	89.26^{c}	95.24^{b}	104.27^{a}	1.17	0.0001	0.3171
Crude protein intake (g/d)	499.1^{b}	1090.3^{a}	1055.9^{a}	0.81	<0.0001	995.6^{c}	1062^{b}	1161.8^{a}	1.27	0.0001	0.3900
Initial weight (kg)	204.72	205.67	205.72	1.89	<0.9642	206.33	206.17	203.61	1.89	0.9642	0.9264
Final weight (kg)	231.50^{b}	262.06^{a}	272.83^{a}	2.94	<0.0001	239.00^{c}	252.67^{b}	274.72^{a}	2.94	0.0001	0.0094
Total weight gain (kg)	26.78^{c}	56.39^{b}	67.11^{a}	2.16	<0.0001	32.67^{c}	46.50^{b}	71.11^{a}	2.16	0.0001	0.0005
Daily gain (kg)	0.43^{b}	0.93^{a}	1.08^{a}	0.03	<0.0001	0.73^{b}	0.77^{b}	0.95^{a}	0.03	0.0001	0.0939
FCR (kg feed DM/kg gain)	11.77^{a}	10.5^{b}	7.40^{c}	0.35	<0.0001	9.14	9.35	8.35	0.43	0.2369	0.1644

P1- grazing alone, P2–grazing plus supplementation, P3-full feedlot
a-c Means with different superscripts within a row differed significantly (P<0.05). SEM = standard error of the mean,
*FCR- feed conversion ratio, S1- 45 days, S2- 60 days, S3- days FP*SP- interaction effect between finishing practices and slaughter periods*

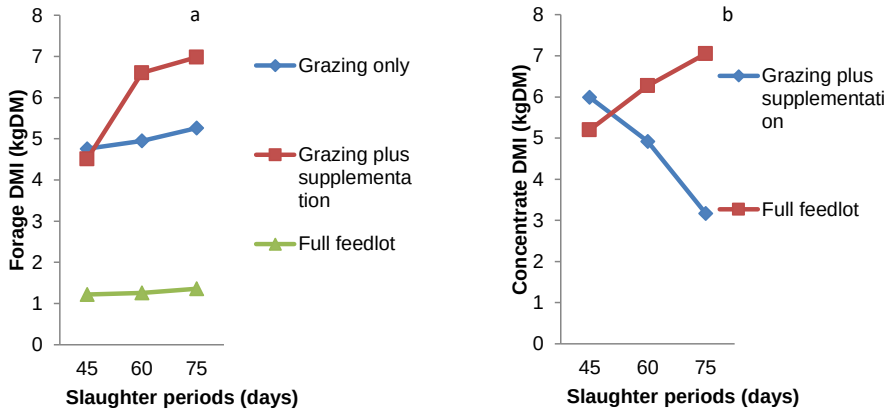

Figure 1. Trends of the forage "a" and concentrate "b" dry matter intake by Boran crossbred bulls as influenced by finishing practice and slaughter period

The mean differences in initial live weights of bulls were neither significant (P>0.05) between finishing practices nor slaughter periods. Bulls on P3 showed the highest (*P*<0.05) average final weight, total weight gain, and daily weight gain, followed by those on P2, and the lowest mean value was observed on the bulls on P1. However, the Lsmeans for final weight and daily weight gain (ADG) of the bulls on P2 were not different (P>0.05) from those on P3. The Lsmeans of feed conversion ratio (FCR) was highest (P>0.05) in bulls on P1, followed by those on P2, and least in bulls on P3. Bulls slaughtered on the 75th day (S3) had higher (P<0.05) average final weight, followed by those on the 60th day (S2) and least with those on the 45th day (S1). Moreover, as the number of days on feed increases, the daily gain also increases as expected, with animals slaughtered on S3 exhibiting the highest (P<0.05) average daily gain, followed by those on S2 and least with those on S1. The FCR by the bulls was not influenced (P>0.05) by the time of slaughter. Significant interaction effects (*P*<0.05) between the finishing practices and slaughter periods were noted on the final body weight and weight gain of the bulls (Table 3). Bulls on the grazing alone (P1) gained weight slowly but consistently throughout the finishing period (Figure 2(a)). However, at the early stages of the finishing period (S1), bulls on feedlot (P3) gained weight slightly lower than those on grazing plus supplementation (P2), leading them to have lower final weight than those on P3. As the time of finishing advanced to S2 and S3, bulls on P3 gained body weight at a rate of 9 and 21 percent, ~~respectively~~ respectively, than those on ~~P2~~ P2, leading them to have higher final weights than those on P2 during those periods (Fig. 2(b))

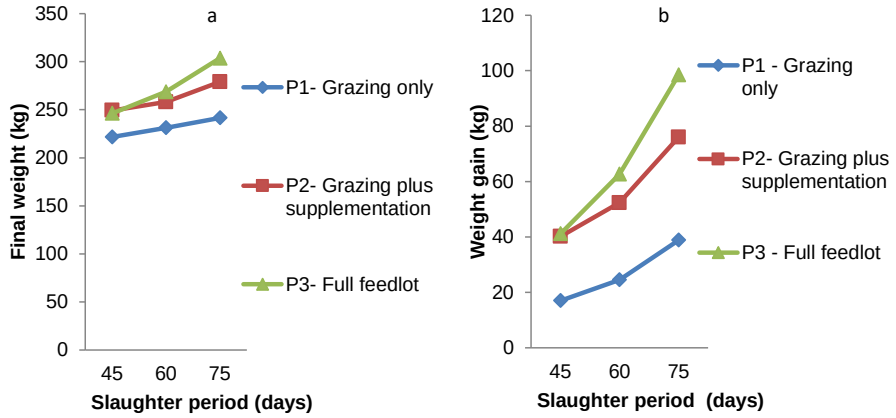

Figure 2. Trends of the final weight "a" and total weight gain "b" of Boran crossbred bulls as influenced by finishing practice and slaughter period

3.3. Slaughter and carcass characteristics

The results of slaughter characteristics of Boran crossbred bulls raised on the different finishing practices are given in Table 4. Bulls finished under practices P2 and P3 had higher ($P<0.05$) mean slaughter weight and empty body weight (EBW) than those in Practice P1. Nevertheless, the mean differences between P2 and P3 on the two parameters were not significant ($P>0.05$). The average weight of the hot carcasses (HCW) of the bulls on P3 was highest ($P<0.05$), followed by those on P2 and lowest in those on P1. Bulls fed for a much longer period and slaughtered at 75 days (S3) produced heavier ($P<0.05$) mean slaughter weight and HCW than those slaughtered at 45 and 60 days of the experiment. However, the mean values of slaughter weight and HCW were similar ($P>0.05$) for the bulls slaughtered at 45 and 60 days. The Lsmeans of the dressing percentage were neither affected by finishing practices nor slaughter periods ($P>0.05$). There was no significant ($P>0.05$) interaction effect between finishing practice and slaughter period on all the assessed slaughter and carcass characteristics.

Table 4. The lsmeans ± SEM for slaughter and carcass characteristics of Boran crossbred bulls finished on the three practices and slaughtered at different periods

Parameter	Finishing practices					Slaughter periods (days)				
	P1	P2	P3	SEM	P-value	S1	S2	S3	SEM	*P*-value
Number of observations (n)	18	18	18			9	9	9		
Slaughter weight (kg)	235.34[b]	265.35[a]	270.64[a]	6.98	<0.0047	242.36[b]	253.81[b]	275.17[a]	7.47	<0.0078
EBW (kg)	197.22[b]	226.83[a]	240.28[a]	7.58	<0.0032	210.09	217.32	236.93	8.11	<0.1285
HCW (kg)	121.01[c]	140.35[b]	149.62[a]	3.58	<0.0004	125.88[b]	135.66[b]	149.43[a]	3.83	<0.0118
Dressing Percent	52.12	52.82	53.68	1.14	<0.4822	51.33	53.29	53.99	1.22	<0.3114

P1- grazing alone, P2–grazing plus supplementation, P3-full feedlot
a-c Means with different superscripts within a row differ significantly (P<0.05). SEM = standard error of the mean, EBW- empty body weight, HCW- hot carcass weight, S1- 45 days, S2- 60 days, S3- days

3.5 Economics of finishing Boran crossbred bulls

The Lsmeans of the economics of finishing Boran crossbred bulls under different practices and slaughter periods are summarized in Table 5. Finishing bulls on grazing alone (P1) resulted in 18% and 11% lower (P<0.05) revenue compared to those on feedlot (P3) and grazing plus supplementation (P2), respectively. The production cost was highest (P < 0.05) for bulls on P3, while it was lowest for those on P1. The gross margins from the bulls finished under the different practices did not differ significantly (P > 0.05), although bulls on P2 had numerically higher (P>0.05) gross margins than their counterparts. The highest (P<0.05) profit per carcass was shown by the bulls on P2, surpassing those on P1 by more than two-fold. Furthermore, bulls subjected to P2 and P3 fetched higher profits per finishing day (*P*<0.05) than those on P1.

Table 5. Least square means ± SEM of the economics of finishing Boran crossbred bulls under different finishing practices and slaughter periods (TZS x 10^6)

	Finishing practices					Slaughter periods (days)					FP*SP
Parameter	**P1**	**P2**	**P3**	**SEM**	***P*-value**	**S1**	**S2**	**S3**	**SEM**	***P*-value**	***P*-value**
Number of observations (n)	18	18	18			9	9	9			
Total revenue	1.06^{c}	1.19^{b}	1.30^{a}	0.031	0.0002	1.07 ^{c}	1.19^{b}	1.29^{a}	0.031	0.0009	0.8445
Total variable costs	0.68^{c}	0.77^{b}	0.92^{a}	0.015	0.0001	0.76^{b}	0.78^{a}	0.83^{a}	0.015	0.0008	0.0080
Gross margin	0.38	0.41	0.38	0.024	0.5972	0.31	0.41	0.46	0.025	.0.051	0.8949
Cost per kg meat	0.0058^{b}	0.0059^{b}	0.0064^{a}	0.0001	0.0074	0.0064 ^{a}	0.0059^{b}	0.0058^{b}	0.0001	0.019	0.4953
Profit per kg meat	0.0032^{a}	0.0031^{a}	0.0026^{b}	0.0001	0.0074	0.0026^{b}	0.0031^{a}	0.0032^{a}	0.0001	0.019	0.4953
Profit per carcass	0.082^{b}	0.19^{a}	0.18^{a}	0.017	0.0003	0.087^{c}	0.14^{b}	0.22^{a}	0.017	<0.0001	0.3085
Profit/finishing day	0.001^{b}	0.003^{a}	0.003^{a}	0.0002	0.0001	0.0019 ^{b}	0.0024^{ab}	0.0029^{a}	0.0002	0.020	0.7263

1 TZS ≈ USD 3.876 x 10^{-4}

P1- grazing alone, P2–grazing plus supplementation, P3-full feedlot

*a-c Means with different superscripts within a row differ significantly (P<0.05). SEM = standard error of the mean, S1- 45 days, S2- 60 days, S3- days, FP*SP- interaction effect between finishing practices and slaughter periods*

The revenue accrued was lower for bulls who finished for a shorter period (S1) and highest for those who finished for a much longer period (S3). The total costs of production assessed at different slaughter periods were lower (P<0.05) for bulls slaughtered early (S1) and higher (P<0.05) for those slaughtered at 60 (S2) and 75 (S3) days of the experiment. There was a significant (P<0.05) interaction effect between the finishing practices and slaughter periods on the total costs of production. Bulls on P2 and those on P1 incurred similar (P>0.05) production expenses at S1, but as finishing time advanced as finishing time advances, P2 incurred slightly higher costs but consistently throughout the finishing duration. Bulls on P1 consistently maintained the costs incurred from S1 to S3. However, from the early stage of the finishing period (S1) to the late S2 and S3, bulls on feedlot (P3) incurred relatively higher production costs than those on grazing plus supplementation (P2) and grazing alone (P1), leading them to have higher costs than P1 and P2 in these periods (S2 and S3) (Figure 3). The mean differences in gross margins between the slaughter periods were not significant (P>0.05). The expenses incurred in producing 1 kg of meat were significantly higher, giving less (P<0.05) profit per kg carcass when bulls were slaughtered at S1 compared to those slaughtered at S2 and S3. Bulls on S3 exhibited the highest profit per carcass compared to those on S2 and S1. Furthermore, in comparison to S1 bulls, animals slaughtered on S2 and S3 displayed noticeably higher (*P*<0.05) daily finishing profit than those on S1.

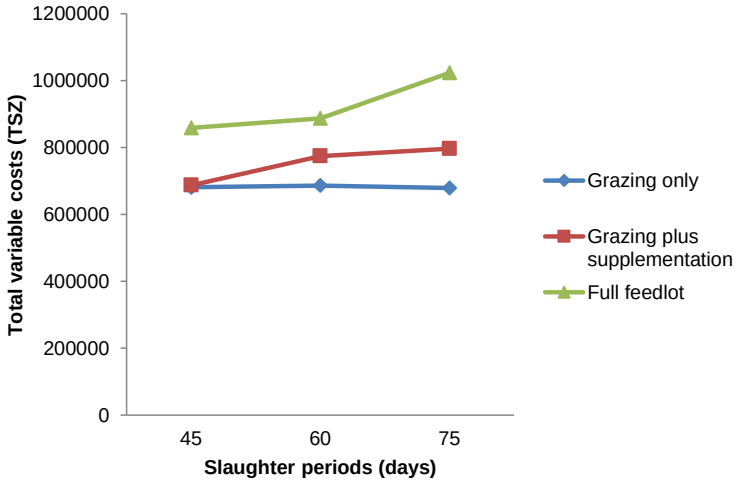

Figure 3. Trends of the total variable costs of finishing Boran crossbred bulls as influenced by practice and slaughter period

4. DISCUSSION

The obtained crude protein (CP) content in the experimental diet was higher compared to the recommended values by [12] for finishing cattle. This is due to the high inclusion of sunflower seed cake (SSC), which has the highest CP content among the dietary ingredients used to formulate the ED. These findings are consistent with previous studies [19]. The ME content of the ED slightly exceeds the recommended value for beef finishing rations, as reported by [12]. Indicating that the ED provides sufficient energy level requiredThis indicates that the ED provides sufficient energy levels for finishing beef cattle. Feeding the ED *ad libitum* to the grazing plus supplementation (P2) and the feedlot (P3) bulls resulted in a marked difference in protein and energy intake of 1090 g/d and 1056 g/d and 95 MJ/d and 97 MJ/d, respectively, between these bulls compared to those on grazing alone (P1) (499 g/d and 42 MJ/d). As a result, bulls on P2 and P3 obtained adequate energy that enabled increased live weight from 205 to 262 kg and 205 to 272 kg, respectively. This demonstrates that bulls on P2 and P3 did well in the tested practices with P3 doing the best. These two practices could be used for finishing the Boran crossbred bulls for increased beef yield. The poor growth performance shown by the bulls grazed on natural pasture (P1) is attributed to the poor quality of the forage, evidenced by their chemical composition presented in Table 2, leading to the obtained lowest

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live weight gain from 205 to 231 kg. The concentrations of CP in the natural pastures (NP) and hay were notably higher compared to the values reported by [9] and [20] [21] and comparable to those affirmed by [22]. This is attributed to the presence *of Bracharia sp* and *Chloris gayana* species in the grazing grounds where both grazing and hay harvesting took place. However, the ME content of NP and hay was similar to the values found in the studies conducted by [23] and [21]. The levels of the acid detergent fibre (ADF) and neutral detergent fibre (NDF) in the ED, which indicates the less digestible components of the feed, align with those observed by [21] and [24] in their respective investigations.

The average values of daily gain (ADG) observed on the bulls under P2 and those on P3 in the present study were slightly above those reported by [11] and [20]. This could be attributed to the relatively higher dietary energy (13.54 MJ ME/kg DM) and protein (14.7 %) concentrations in the experimental diet compared to those given by [12]. Similarly, offering a high-dense ration to grazing animals may reduce their daily movement and feed-searching activities and conserve energy for growth [26]. The value of ADG by the bulls on P1 was comparable to the findings of [27], which reported a gain of 0.44 kg/d for Boran cattle on grazing in Ethiopia and higher than the ADG of 0.223 kg/d and 337kg/d reported earlier for TSHZ and Boran x Friesian bulls on grazing in Tanzania [24-28]. The NP and hay used in the present study contained lower ME contents than the recommended levels for finishing beef cattle, resulting in the lowest daily gain, body weight gain, and final weight in grazing bulls compared to those raised in feedlots and supplemented with concentrate. The study by [23] showed that natural pastures are abundant during the wet season but scarce and of low nutritional value during the dry season, leading to variations in weight gain, slaughter, and carcass weights of finished animals [29]. Therefore, supplementing animals at Kidago Farm is crucial in order to supply adequate nutrients for maintenance and production. Subsequently, finishing cattle in feedlots or combining grazing with concentrate supplementation could be an appropriate strategy that enables cattle to attain their ideal slaughter weight earlier compared to finishing on sole grazing.

The obtained lower efficiency of feed utilization (high FCR) for bulls on P1 might be due to the consumption of grass, and forage probably fibrous with poor digestibility. The observed values of FCR shown by the bulls on P3 and those on P1 are comparable to the values reported by [29], ranging from 6.3 to 8.2 and 9 to 17, respectively, for the feedlot study in Uganda. The mean value of FCR by bulls on P3 is in agreement with the value (7.87) reported by [20] on Tanzania shorthorn zebu steers finished on feedlot using five compounded diets. The improved efficiency of feed utilization observed in bulls on P3 could be due to the relatively higher intake of the ED with the energy of 13.53 ME, MJ/kg DM, and 14.7 % CP~~, h~~. Hence, more digestible and efficiently utilized by the bulls. The values of FCR improved with increased slaughter durations, having efficient feed utilization (8.35) S3. This is because it takes time for the rumen microbial population to fully adapt and become more efficient at digesting the high-energy rations, having more time in the feedlot leads to improved microbial efficiency and improved feed utilization.
Finishing practice by slaughter period interaction (Table 3) for dry matter intake was due to increased DMI with advancing slaughter periods from 45 to 60 days in P2 and P3 bulls. ~~The concentrate supplementation improves forage DMI dramatically~~Concentrate supplementation improves forage DMI dramatically and, hence, animal performance. ~~Comparing~~ Compared with the feedlot, grazing with supplementation reduces the intake of concentrate, leading to lowering costs of production. Similar to the present results, [25] found significant interaction effects on nutrient intake when Simmental cross steers were compared under intensive and extensive feeding regimes and slaughtered at different time intervals.

The higher values of slaughter weight observed on the bulls on P2 and those on P3 than those on P1 across the slaughter periods are attributed to the type of feeds and the way animals were fed. The ED offered *ad libitum* to bulls after grazing (P2) and in feedlot (P3), which influenced higher weight gain and final weight. The observed values of slaughter weight in the present study are in agreement with those reported by [22] in Ethiopia for Boran bulls on feedlot and sole grazing and those of TSHZ in Manyara, Tanzania [24]. The mean values of EBW observed in all practices and slaughter periods in the present study were within the range of 163 to 263 kg reported by [11] and [20] on TSHZ bulls and Boran cross steers, respectively.

The observed mean values of HCW in the present study were similar to the values reported by [29] on three cattle strains finished on a feedlot and slightly higher than their cohort grass-grazed bulls. The ED fed to bulls on practices P2 and P3 contained higher energy and protein contents

above the requirements for cattle fattening and could be the cause of the higher values of HCW obtained in the present study. The bulls on P1 grazed on forages having energy of 8.43 ME MJ/kg DM and protein of 10% that are below the beef cattle nutrient requirement for finishing, hence leading to slower growth and hence observed low values of HCW. The mean values of dressing percentage observed in the current study were similar in both finishing practice and slaughter period and are comparable to those reported by [29]. The figures of DP in this study were slightly higher than those obtained by [22] on Arsi, Boran, Harar, and Holstein Friesian Crosses cattle breeds finished under a similar level of concentrate supplementation in Ethiopia. The probable cause of the difference in DP might be owing to the age of the bulls used in the present study (2.5-3 years) being matured and having a higher bone-to-muscle ratio which improves the dressing percentages. When animals mature and are exposed to a high-energy diet, the muscle mass and fat cover increase, leading to improved dressing percentage [30].

The observed highest total variable costs on P3 bulls could be related to the highest concentrate intake compared to bulls on P2. The expenses incurred in compounding ED were associated with the highest variable cost observed on P3 bulls. The bulls on P2 showed higher revenue and gross margin which might be linked to the moderate variable costs incurred in feeding these bulls due to the use of the low amount of formulated diet plus grazing on the range, which is low in cost compared to bulls on P3. Providing concentrate after grazing allowed the animals to consume essential nutrients; including energy, protein, vitamins, and minerals that may be lacking or insufficient in their daily grazing. In addition, feeding cattle concentrate after grazing helps to reduce the regurgitation time as concentrate cuds are easily chewed due to small particle sizes, are less fibrous, and are more readily digestible than fibrous plants. The supplementation of concentrate in bulls on P2 led to high efficiency in rumen function hence increased production of volatile fatty acids and microbial protein useful for providing additional energy and protein to the animal [31]. The bulls on P2 proved economically sound as they generated higher profit per carcass and per day of finishing compared to their counterparts. However, the observed lower profit per kg of beef produced by the bulls on P3 compared to those on P2 implies that feedlot operations incur significantly higher expenses per kg of weight gain compared to grazing and supplementation. Therefore, combining grazing with concentrate supplementation represents a cost-effective finishing practice and can serve as an alternative to the costly feedlot approach.

The lowest variable costs and revenue obtained from sole grazing bulls (P1) were associated with the lowest carcass gain owing to a slower growth rate leading to the lowest daily gain, total weight gain, and final weight attained upon study completion. Finishing beef cattle on grazing is cheap as forage are freely available feed resource with varying nutritive intakes hindering short-duration attainment of slaughter weight [32]. Hence, offering a rich energy diet and allowing animals to have free access to grazing on rangeland have shown improved weight gain [33]. The results from the current study concur with the previous investigations by [34] indicating that livestock producers generally face significant expenses related to feed among other factors, particularly when animals are intensively finished. However, the interaction between finishing practices and slaughter periods was not significant in all assessed profitability parameters except for total variable costs, which are a fundamental measure in beef production economics. Results obtained from the present study were similar to findings reported by [35] and could be linked to the costs of producing experimental diet, the amount consumed, and its efficiency of utilization. The concentrate supplementation improves feed utilization efficiency which encourages forage intake, thus improving growth rate and lowering the costs of production compared to feedlot.

The higher values of daily gain, weight gain, and final weight attained by bulls on S3 compared to those on S2 and S1 have resulted in relatively higher revenue and gross margin. This trend could be associated with the provision of a high-dense concentrate diet for bulls on P2 and P3 in such a finishing length leading to an increased body weight mass and gross margin. Therefore, this study demonstrated that, in feedlot enterprises, there is potential for higher weight gain and daily gain in Boran crossbred bulls finished on feedlot (P3) and supplementation (P2) practices. The study also highlights that the use of these research findings by farmers and feedlot practitioners substantially contributes to the development of the beef sub-sector through increased prime beef production in the country.

5. CONCLUSION AND RECOMMENDATION

It is concluded that improved growth performance and carcass yield from Boran crossbred bulls are achieved through finishing the bulls for 75 days under feedlot and grazing coupled with concentrate supplementation practices. Finishing bulls on grazing and concentrate supplementation is, however, more profitable than full-feedlot practice. For enhancing productivity of beef, therefore stakeholders in the beef sector advised to opt for the combination of grazing and supplementation with well-balanced concentrate in finishing Boran crossbred bulls for 75 days. Proposed further studies should focus on the assessment of the quality of the produced beef and evaluation of the finishing strategies of other improved beef breeds of cattle.

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