Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 9 ~ Issue 12 (2022) pp: 34-43
ISSN(Online) : 2321-9459
www.questjournals.org

Research Paper

Evaluation of locally available feed resources for fattening of zebu cattle in the Lake zone of Tanzania

Alex Goodluck Mrema[1], Sebastian Wilson Chenyambuga[2*], Esron Karimuribo[3], Angaza Gimbi[4] and Lughano Jeremy Moses Kusiluka[5]
[1]Livestock Training Agency, Mabuki Campus, P.O. Box 115, Misungwi, Tanzania.
[2]Department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture, P.O. Box 3004, Morogoro, Tanzania.
[3]Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture, P.O. Box 3021, Morogoro, Tanzania.
[4]Faculty of Science, Technology and Environmental Studies, The Open University of Tanzania P.O. Box 23409, Dar es Salaam, Tanzania.
[5]University of Dodoma, P.O. Box 259, Dodoma, Tanzania.

ABSTRACT: *A feeding experiment was conducted to assess the suitability of locally available feed ingredients for cattle fattening in Tanzania. The diet ingredients were maize meal (MM), molasses (MO), maize bran (MB), rice polishing (RP), cotton seed hulls (CSH) and cotton seed cake (CSC). Five diets were formulated using these ingredients with the aim of replacing the expensive MM and MO with MB, RP and CSH which are cheap. Diet one (MM-MO) was a control and contained MM and MO as the energy sources. Diet two (MB-CSH) contained CSH and MB while diet three (RP-CSH) had CSH and RP as the main sources of energy. Diet four (MB-RP-CSH) contained CSH, MB and RP while diet five (CSH) contained only CSH as the main source of energy. All diets contained CSC as a source of protein and mineral mix and salt. Fourty (40) Tanzania Shorthorn zebu bulls aged three to four years with average initial weight of 172.6 ± 6.1 kg were used in the experiment. The animals were allocated to the five diets in a completely randomized design and the experiment took 80 days. Eight animals were randomly assigned to each diet. Mean dry matter feed intake (FI), weight gain, feed conversion ratio (FCR), average daily weight gain (ADG) and gross margin (GM) were computed for each treatment. The average FI (5.58 kg DM/d) and FCR (10.3) were higher ($P \leq 0.05$) for the bulls fed CSH diet compared to those on other diets. Animals on CSH had lower ($P \leq 0.05$) weight gain (41.4 kg) and growth rate (0.58 kg/d) than those on the other diets. The highest ADG was observed on bulls on MM-MO (0.90 kg/d), followed by those on MB-CSH (0.86 kg/d) and MB-RP-CSH (0.83 kg/d). The bulls fed diet MM-MO had the highest feed cost per unit weight gain (TZS 3,403) and lowest GM (TZS -39,235 per animal) whereas those on MB-RP-CSH had the lowest feed cost per unit weight gain (TZS 1,436) and highest GM (TZS 71,414 per animal). Therefore, diet MB-RP-CSH was better than the other diets. It is concluded that, the mixture of cotton seed hulls, rice polishing and maize bran can replace maize meal and molasses as sources of energy in cattle fattening diets.*
KEYWORDS*: Feed intake, feed conversion ratio, gross margin, growth rate, Tanzania Shorthorn Zebu*

R*eceived 06 Dec., 2022;* ***R****evised 18 Dec., 2022;* ***A****ccepted 20 Dec., 2022*
P*ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

In Tanzania, about 98% of beef is produced from indigenous breeds of cattle, namely Tanzania Shorthorn zebu and Ankole, kept under extensive production system. This system is characterized by low input supply in terms of feeds, veterinary drugs and poor general management practices. Beef production under extensive system is affected by shortage of forage, especially during the dry season since animals depend entirely on natural pastures. During the dry season, the quantity and quality of natural pastures are low and animals fed on these pastures have low growth rate, poor body condition score and are emaciated, and thus produce low quality meat [1] and [2]. Poor quality meat fetches low price in the markets, hence, low income to farmers [3], [4] and [5].

In recent years, cattle fattening has emerged as a method for value addition of indigenous cattle breeds in Shinyanga, Simiyu Geita and Mwanza regions of Tanzania [4] and [5]. Fattening in these areas is used to add value to mature and emaciated cattle purchased from pastoralists and agro-pastoralists. The animals are supplemented with concentrate feeds in order to improve body weight gain, body condition score and the quality of beef. The national ranching company (NARCO) and private owned large-scale farms practice cattle fattening in order to counteract the effects of feed shortage during the dry season and improve meat quality. There are also few small-scale livestock keepers and traders who mostly fatten mature cattle through grazing and supplementation with agro-industrial by-products. Varieties of feeds are used for supplementation of cattle being fattened. Conventional concentrates such as cereal grains, molasses, oil cakes and other cereal agro-industrial by-products are used in commercial beef production to improve performance of animals under fattening [6]. The use of conventional concentrates has two major limitations; the ever-increasing price, and limited supply of cereal grains due to competition for use as human food and main ingredients in monogastric rations. In the traditional system, livestock traders buy animals of lower grades from producers in the primary livestock markets at lower prices and feed them with cotton seed cake, cotton seed husks, rice polishing and/or maize bran for three to four months before selling them at higher prices in secondary and tertiary markets or slaughter houses [4]. Under this traditional fattening system, animals are fed *ad libitum* amount of these agro-industrial by-products.

In the past, cotton husks, rice polishing and maize bran were readily available, cheap and could sometimes be costless with no economic value attached to them and were seen as wastes causing industrial burden and pollutant to the environment [6]. However, due to the increasing practice of cattle fattening in Mwanza, Geita, Simiyu and Shinyanga regions, the demand and price of these agro-industrial by-products have increased [4]. This necessitates planning for their optimal and efficient use in order to obtain optimum animal performance at lower cost and maximize profit. *Ad libitum* feeding coupled with high price of the feed ingredients make traditional cattle fattening not economically efficient.

So far, there is no research that have been done in the Lake zone of Tanzania to establish or determine the optimum inclusion levels of the locally available feed materials in cattle fattening rations. Moreover, there is no standard diet recommended for cattle fattening under the traditional sub-sector in Tanzania [7] and [8]. The types of feed materials and their amount used in the diets vary considerably among cattle fattening operators, leading to finished animals having different qualities. Hence, there is a need to formulate a cheap and well-balanced concentrate diet (that will meet beef cattle requirements) based on locally available feed resources in order to enable farmers to produce beef economically and efficiently. This will result into increased production of quality meat and, hence, increase the profitability of traditional fattening system. Therefore, this study was undertaken to evaluate locally available feed resources in Misungwi and Kahama districts located in the Lake zone of Tanzania and develop a cheap but high-quality diet for fattening of indigenous cattle in agro-pastoral communities.

II. MATERIALS AND METHODS

Description of the study area

The feeding experiment was carried out at Tanzania Livestock Research Institute (TALIRI)-Mabuki in Misungwi district, Mwanza region, Tanzania, which is located at $2^{0}35^{'}$ S, and $32^{0}45^{'}$ to $33^{0}15^{'}$ E. Mean annual temperatures of the area range from 28 to 30^{0}C and the average annual rainfall is between 600 and 800 millimetres.

Animals, experimental design and treatments

Experimental animals were Sukuma cattle bulls. Sukuma cattle are a strain of Tanzania Shorthorn zebu breed found in the Lake zone of Tanzania, south of Lake Victoria. A total of 40 bulls whose age ranged between three and four years with average weight of 172.6 ± 6.1 kg were randomly allocated to five dietary treatments in a completely randomized design. The diets were formulated as indicated in Table 1. The first diet comprised maize meal (MM) and molasses (MO) as main sources of energy and is the best common conventional diet that has been recommended in commercial cattle fattening [9]. This diet had metabolizable energy (ME) of 12.5 MJ/kg DM and crude protein (CP) of 12.5% which are recommended by NRC [10] and was expected to produce average daily body weight gain of 1.0 kg/day. The second, third and fourth diets were balanced rations formulated using locally available feed ingredients while the fifth diet (the control diet) was formulated based on farmers' feeding practice in Misungwi and Kahama districts. The major energy sources in diet two were maize bran (MB) and cotton seed hulls (CSH) while in diet three were rice polishing (RP) and CSH and in diet four were MB+ RP + CSH. In diet five CSH was the only major source of energy. All diets contained cotton seed cake (CSC) as the source of protein. The least cost feed formulation method was used to determine the inclusion levels of the various ingredients required to obtain the desired crude protein (12% CP) and energy (12.5 ME MJ/kg DM) levels that would meet the requirements of beef cattle. The diets were considered as treatments.

Four bulls were randomly allocated to each treatment and each treatment was replicated twice, making a sample size of eight animals per treatment and the total sample size of 40 bulls. The groups of the experimental bulls were later allocated randomly to the feeding pens. All feeds provided were measured and refusals were collected just before the next feeding. Feed intake and feed conversion ratio were computed for individual animals.

Table 1. Proportions of various feed ingredients in the experimental diets

Feed ingredients	Treatment				
	MM-MO (%)	MB-CSH (%)	RP-CSH (%)	MB-RP-CSH (%)	CSH (%)
Maize meal (MM)	38	0	0	0	0
Cotton seed cake (CSC)	13	15	15	15	15
Cotton seed hulls (CSH)	-	37	37	30	83.5
Rice polishing (RP)	0	0	45	30	0
Maize bran (MB)	0	45	0	22	0
Molasses (MO)	47	0	0	0	0
Mineral mix	2	2	2	2	0
Salt	1	1	1	1	0
Urea	0.5	0	0	0	0
Local salt	0	0	0	0	1.5
Total	**100**	**100**	**100**	**100**	**100**

Note: MM-MO = diet one containing maize meal and molasses as energy sources
MB-CSH = diet two containing maize bran and cotton seed hulls as energy sources
RP-CSH = diet three containing rice polishing and cotton seed hulls as energy sources
MB-RP-CSH = diet four containing maize bran, rice polishing and cotton seed hulls as energy sources
CSH = diet five containing cotton seed hulls as the only energy source

Management of animals

The experimental animals (Sukuma cattle bulls) were bought from primary markets in Misungwi district. The feed ingredients used to formulate the treatment diets were bought from milling machines, ginneries and animal feed shops in Mwanza and Shinyanga cities. Upon arrival at the experimental station, the animals were dewormed using NILZAN anthelmintic suspension to control endoparasites and sprayed with acaricide (Dominex 50% EC) to control external parasites. All animals were sprayed with acaricide twice per week throughout the experimental period. All animals assigned to each treatment were provided with the respective treatment diet for 10 days to familiarize them to the new diet and feed intake was adjusted before the actual feeding trial and data collection started. During the last three days of the preliminary period, all animals were weighed consecutively to obtain average initial weights. In both preliminary and experimental periods, the bulls were grazed on natural pastures in a 250 ha area from 0800 h to 1400 h and then supplemented *ad libitum* with the respective treatment diets. The data collection period took 70 days after the preliminary period of 10 days. Fresh feeds offered were measured and refusals were collected and measured. Both feeds offered and refusals were measured daily using a weighing balance. All animals had access to clean water three times per day.

Determination of feed intake, feed conversion ratio and growth rate

The average daily feed intake (FI) in kg DM per animal for each treatment was calculated as the total feed provided in each pen minus feed refusal (kg) divided by the number of animals per pen (four bulls). Feed conversion ratio (FCR) per animal in each treatment was calculated as DM feed intake per animal (kg) divided by weight gain (kg). Body weights of the individual experimental bulls were taken and recorded every week in the morning before grazing and concentrate feeding. Average daily gain (ADG) per animal was calculated as final weight minus initial weight in kg divided by 70 days of the experimental period.

Determination of chemical composition and *in vitro* digestibility of feeds

The samples of the treatment diets and natural pasture from grazing area were analysed for dry matter (DM), ash, crude protein (CP), ether extract (EE) and organic matter (OM) contents according to the standard procedures of AOAC [11] at the animal nutrition laboratory, department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al*. [12]. *In vitro* dry matter digestibility (IVDMD) and *in vitro* organic matter digestibility (IVOMD) were determined in accordance to Tilley and Terry

[13] procedures. Metabolizable energy of the supplementary diets was calculated according to MAFF [14], i.e. ME (MJ/kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE, where CP, EE, CF and NFE are in g/kg DM. The metabolizable energy of grazed natural pasture was calculated according to McDonald *et al*. [15] as ME (MJ/kg DM) = 0.016 DOMD, whereby DOMD (g) is digestible organic matter per kilogram of dry matter.

Assessment of body condition score

Body condition score (BCS) for each animal was observed progressively and recorded at the start, on the fourth week and last week of the feeding trial as recommended by Nicholson and Butterworth [16]. All animals were individually scored using a nine-point scale, the lowest score was one (highly emaciated) and the highest score was nine (very fat).

Gross margin analysis

Gross margin (GM) analysis was used to determine profitability of the bulls fattened using the five diets and was calculated as;

GM = GI – VC

Whereby GM = Gross margin, GI = Gross income, VC = Variable costs.

In calculating the Gross Income per animal, the following formula was used;

GI = Ps*(We) - Wb*(Pp)

Whereby Wb = Average live weight (LW) of bull in kg at the beginning of the fattening period, We = Average LW of the bull in kg at the end of the fattening period, Pp = Average purchasing price for one kg LW of a bull in TZS before fattening and Ps = Average selling price for one kg LW of the bull in TZS at the end of the fattening period.

Because of imperfections in livestock auction markets such as average pricing for a group of animals, and use of visual appraisal to estimate price of animals, each bull was valued based on price of one kg of live body weight in order to have uniform pricing system [17]. The total cost for purchasing an animal was divided by the total body weight of the bull in order to establish the price of buying one kilogram of live weight of the bulls. At the end of the experiment all bulls were sold at livestock markets. The selling price of the bulls were recorded and divided by their final body weight to establish selling price per kg live weight.

The cost per kg of each experimental diet was determined by adding the prices of the individual ingredients used in diet formulation. The total feed cost per animal in each treatment was determined by multiplying the average cost of one kg of the diet with the average feed intake per animal per day and the number of experimental days. The average cost of feed per kg live weight gain was determined by dividing the average total cost of the feed consumed during the experimental period by the weight gained by an animal.

All other variable costs including labour, veterinary drugs, transportation of feeds and animals and miscellaneous costs were summed up and averaged per individual experimental animal. Assumption was made that most traditional fatteners graze their animals in communal grazing areas at zero cost; hence, no cost was added for grazing pasture.

Statistical analysis

Data generated on growth performance parameters (FI, FCR, ADG and BCS) were analysed using GLM procedure of SAS [18]. Initial weight of an animal was used as covariate in a completely randomized design and the effect of diet was assessed as a fixed factor. Least significance difference (LSD) was used to determine the significance of the differences between a pair of treatment means.

III. RESULTS

Nutritive value of supplementary diets and natural pasture

The results in Table 2 show the chemical composition of experimental diets. The CP content varied among the diets and diet MB-CSH had the highest value, followed by MM-MO, MB-RP-CSH and RP-CSH while diet CSH had the lowest. It was revealed that MB-CSH had the highest EE whereas MM-MO had the lowest value compared to the other diets. Diet CSH had the highest CF and ADL compared to MB-CSH, RP-CSH and MB-RP-CSH while MM-MO had the lowest value. Ash content was highest in RP-CSH whereas CSH had the lowest value among the diets. The diet MM-MO had the highest ME, followed by MB-CSH, MB-RP-CSH and RP-CSH whereas CSH had the lowest. The *in vitro* dry matter digestibility (IVDMD) and organic matter digestibility (IVOMD) were higher in formulated diets MM-MO, MB-CSH, MB-RP-CSH and RP-CSH compared to CSH which had the lowest value. Natural pastures from the area in which the animals were grazed had high DM and NDF and low CP content, IVDMD and IVOMD. The ME of pastures was also found to be lower than that of the supplementary diets.

Effects of dietary treatment on feed intake and growth performances of fattened bulls

Table 3 shows the effects of dietary treatment on performance of fattened bulls. The analysis of variance revealed significant differences among the experimental diets with respect to feed intake. The results show that animals fed diet CSH had the highest average feed intake per animal (5.58 kg DM/d) while those on diet MB-CSH had the lowest (4.07 kg DM/d) intake compared to those on the other diets. However, the feed intake of animals fed diet MB-CSH was not different ($P > 0.05$) from that of animals given diet MB-RP-CSH.

The experimental diets significantly influenced body weight gain of fattened bulls. The bulls on diets MM-MO, MB-CSH and MB-RP-CSH had higher ($P \leq 0.05$) weight gain compared to those on diet RP-CSH and the control diet CSH. Similar results were observed on growth rate, whereby animals offered MM-MO, MB-CSH and MB-RP-CSH diets had higher ($P \leq 0.05$) ADG compared to those offered RP-CSH and CSH. The highest ADG (0.90 kg/d) was observed on the bulls fed diet MM-MO, but their ADG was not significantly different from that of animals fed MB-CSH and MB-RP-CSH diets. The ADG of animals fed the control diet CSH was the lowest (0.58 kg/d), but it was not significantly different from that of those offered RP-CSH. The FCR varied among the treatment diets. The highest FCR (10.3) (the poorest feed utilization) was found in animals fed diet CSH and differed ($P \leq 0.05$) from the FCR of the animals fed other diets. Moreover, the results show that diets MM-MO, MB-CSH and MB-RP-CSH were better utilized ($P \leq 0.05$) in being converted to live weight compared to RP-CSH. Diet MB-CSH was more efficiently utilised and had the lowest FCR of 4.07 compared to the other diets. The results indicate that there was significant difference in final BCS among the animals under different treatments. Bulls fed diets MM-MO, MB-CSH and MB-RP-CSH had higher ($P \leq 0.05$) BCS values than those on diets RP-CSH and CSH. Animals on diet MM-MO had the highest (8.18) final BCS whereas those on diet CSH had the lowest value (6.64).

Table 2. Chemical composition, energy content and digestibility of experimental diets and natural pasture

	MM-MO	**MB-CSH**	**RP-CSH**	**MB-RP-CSH**	**CSH**	**Natural pasture**
Chemical composition						
DM (g/kg DM)	935	941	951	936	922	926
CP (g/kg DM)	124	141	73.1	115	62.8	62.1
EE (g/kg DM)	33.2	77.0	53.9	70.8	51.9	17.2
CF (g/kg DM)	37.9	248	346	251	409	291
ADF (g/kg DM)	66.0	297	412	337	493	343
NDF (g/kg DM)	282	565	564	700	688	688
ADL (g/kg DM)	13.3	68.8	83.0	70.4	114	37.0
ASH (g/kg DM)	105	64.4	116	103	52.3	84.5
NFE (g/kg DM)	635	399	362	397	339	-
Energy						
ME (MJ/kg DM)	11.6	10.9	9.35	10.4	9.15	6.08
Digestibility						
IVDMD (%)	88.7	60.0	51.7	53.4	34.9	42.5
IVOMD (%)	83.8	53.7	45.3	46.9	28.2	38.0

Note: DM = Dry matter, CP = crude protein, EE = ether extract, ADF = acid detergent fibre, NDF = neutral detergent fibre, ADL = acid detergent lignin, CF = crude fibre, NFE = nitrogen free extract, ME = metabolizable energy, IVDMD = *in vitro* dry matter digestibility, IVOMD = *in vitro* organic matter digestibility

Gross margin analysis of fattened bulls

Table 4 presents the incomes, variable costs and gross margins of fattened bulls for each treatment. The prices per kg live weight of the experimental bulls before and after fattening were TZS 1290 and 1917, respectively. In this study diet MM-MO had higher ($P \leq 0.05$) feed costs compared to the other diets. The feed cost for diet RP-CSH was lower ($P \leq 0.05$) compared to that of the other diets. Other variable costs apart from feed costs were constant for all treatments, hence, the total variable cost followed the same trend as that of feed costs.

The bulls offered diets MM-MO, MB-CSH and MB-RP-CSH had higher ($P \leq 0.05$) gross incomes compared to those offered RP-CSH and CSH. The gross margin was higher ($P \leq 0.05$) for the animals offered diet MB-RP-CSH than that observed for the rest of the treatments. The gross margins for the animals fed diets MB-CSH, RP-CSH and CSH were not different ($P > 0.05$). The gross margin for the bulls offered diet MM-MO was lower ($P \leq 0.05$) than that of animals on the other treatments. The cost of feed per kg weight gain for the bulls offered diet MM-MO was the highest and differed ($P \leq 0.05$) from the feed costs of those offered other diets. It was observed that animals offered diet MB-RP-CSH had the lowest cost of feed per kg weight gain and differed ($P \leq 0.05$) from that of the animals offered the control diet CSH, but did not differ ($P > 0.05$) from that of the animals fed diets RP-CSH and MB-CSH.

Table 3. The effects of supplementary diet on growth performance, feed intake and body condition score of the experimental bulls

Parameter	Treatment					SEM	P - value
	MM-MO	MB-CSH	RP-CSH	MB-RP-CSH	CSH		
Initial LW, kg	184^a	164^b	157^b	166^b	192^a	6.11	0.0009
Final LW, kg	235^a	233^a	215^b	231^a	214^b	3.00	0.0005
ADG, kg/d	0.90^a	0.86^a	0.61^b	0.83^a	0.58^b	0.04	<0.0001
DM intake, kg/d	4.45^c	4.07^d	4.74^b	4.16^d	5.58^a	0.04	<0.0001
FCR	5.11^c	4.76^c	7.73^b	5.05^c	10.3^a	0.50	<0.0001
Initial BCS	2.40	2.30	2.30	2.40	2.80	0.00	0.288
Final BCS	8.18^a	7.80^{ab}	7.09^b	7.92^a	6.64^c	0.30	0.0012

Note: LW - Live weight, ADG - average daily gain, DM - dry matter, FCR - feed conversion ratio, BCS - body condition score

Table 4. Comparison of revenue, variable cost and gross margin of fattened bulls under different treatments

Parameter	Treatment					SEM	P - value
	MM-MO (TZS)	MB-CSH (TZS)	RP-CSH (TZS)	MB-RP-CSH (TZS)	CSH (TZS)		
Revenue							
Sales of fattened bulls	470,906^a	431,902^b	384,058^c	430,464^b	446,198^{ab}	1,240	0.0005
Variable costs							
Purchase of bulls	237,538^a	212,133^b	202,145^b	213,488^b	248,207^a	7,880	0.0009
Feed costs	211,354^a	105,059^b	73,966^e	84,311^d	94,896^c	2,430	0.0001
Other costs[1]	61,250	61,250	61,250	61,250	61,250	-	-
Total costs	510,141^a	378,442^b	337,361^e	359,049^d	404,353^c	2,430	0.0001
Gross margin	-39,235^c	53,460^b	46,697^b	71,414^a	41,845^b	5,880	0.0001
Cost of feed/kg weight gain	3,403^a	1,739^c	1,724^c	1,436^c	2,292^b	140	0.0001

[abcd] Means with different superscript letters within the same row are significantly different at P = 0.05
SEM = standard error of the mean.
[1]Other costs = cost of veterinary drugs, transportation of feeds and animal movement permits

IV. DISCUSSION

Nutritive value of diets used in the experiment

Among the experimental diets, diet MB-CSH had the highest CP content and this could be attributed to inclusion of cotton seed cake (CSC) and maize bran (MB) that contained higher CP relative to the other ingredients. The observed CP values for diets MM-MO, MB-CSH and MB-RP-CSH are within the range of 11 and 14% reported by Cole and Hutcheson [19]**.** This implies that the formulated diets MM-MO, MB-CSH and MB-RP-CSH are more suitable for supplementation of cattle being fattened. According to Rutherglen [20], the CP content of the diet should be between 12.31 and 15.91% to meet protein requirement of fattened cattle and to promote high growth rate. The CP content of natural pasture observed in this study was below 7% and is similar to that reported by Chamatata [6]. This finding indicates that, the natural pastures in the grazing area are of poor quality and cannot alone meet the recommended CP requirements for high performance of beef cattle. Similarly, the diet used by farmers (diet CSH) to supplement fattened animals had CP content that is below the recommended level. Thus, there is a need to supplement grazing animals with concentrates which have high CP content, especially during the dry season.

The results for chemical composition analysis show that diets MB-CSH and MB-RP-CSH had higher EE compared to the other diets. This might be due to high level of MB included in these diets since MB had higher EE content relative to the other ingredients. The EE contents for the diets MB-CSH, RP-CSH and MB-RP-CSH are higher than the maximum recommended level of 6% for mature cattle diets [21]. Despite this high EE level, there were no negative effects such as diarrhoea to the animals.

The observed higher levels of CF and ADL in diet CSH might be due to high inclusion level of cotton seed hulls (CSH) which contained high proportions of those components. The percentages of CF and ADL were slightly less in diets MB-CSH, RP-CSH and MB-RP-CSH because these diets had low level of CSH. Diet RP-CSH had relatively higher CF and ADL compared to MB-CSH and MB-RP-CSH and this is attributed to inclusion of high amount of rice polishing (RP) which contained larger proportions of CF and ADL. The CF in diet MM-MO was below the minimum recommended level of 170 g/kg DM in concentrates for supplementation of beef cattle [10] while diets MB-CSH, RP-CSH, MB-RP-CSH and CSH had CF values that exceeded the minimum required level. Although MB-CSH and MB-RP-CSH had high CF contents, they are more suitable as supplementary diets than RP-CSH and CSH because of having relatively higher levels of CP and ME which is enough to meet the body requirement for microbial activity needed to ferment low quality forage [22] and [23].

The energy (ME) value was highest in diet MM-MO and lowest in CSH. The energy contents in MM-MO, MB-CSH and MB-RP-CSH are within the range of 10 to 13 MJ/kg DM recommended by Rutherglen [20] and NRC [10] for beef cattle. This implies that these diets have adequate energy content and can be used for fattening of cattle. In this study, the IVOMD was higher in diets MM-MO, MB-CSH and MB-RP-CSH. The IVOMD values for these diets are higher than the minimum level of organic matter digestibility (45%) recommended by Kossila [24] for beef cattle feeds. This is probably due to higher and balanced CP and ME levels in these diets. According to McDonald *et al*. [15] optimal protein and energy levels in the diet ensure optimum conditions required for microbial growth to promote digestibility of organic matter in the rumen. Based on the higher digestibility values observed in diets MM-MO, MB-CSH, RP-CSH and MB-RP-CSH it can be said that these diets are more suitable for fattening of cattle compared to the control diet CSH, which is the common diet used by farmers.

Effects of diets on feed intake and growth performances of fattened bulls

The results indicate variations in average daily feed intake among bulls supplemented with the different diets. The feed intake of animals on MM-MO is within the range reported by other authors for molasses and maize based diets [25] and [9]. The concentrate intakes for the bulls offered diets MB-CSH, RP-CSH, MB-RP-CSH and CSH which contained cotton seed hulls are less than the intake of 8.84 and 6.28 kg DM/d reported by Chamatata [6]) and Mawona [8], respectively, for steers fed diets formulated based on cotton seed hulls. The difference in feed intake is attributed to differences in animal body weights and feed formulations that were used in the two experiments. The higher feed intake observed in animals fed diet CSH compared to the intakes of those offered diets MM-MO, MB-CSH, RP-CSH and MB-RP-CSH is due to the fact that diet CSH contained only cotton seed hulls as the source of energy and thus the bulls on this diet ate more in order to compensate for the energy deficit of CSH and meet body requirements [26] and [15]. Furthermore, the high palatability of CSH coupled with its high passage rate [27] and [28] possibly resulted into the high voluntary intake of the low energy density but highly fibrous supplement. This is contrary to the notion that high fibre feedstuffs like CSH depress feed intake as they take up space and limit the capacity of the rumen [15].

The CP and energy contents of diets MM-MO, MB-CSH, and MB-RP-CSH were within the range recommended by NRC [10] and thus could support microbial activity for increased intake of poor forage. According to Rowe *et al*. [29] when animals feeding on low quality roughage are supplemented with concentrates containing adequate amount of nutrients such as CP and ME, the intake of the basal diet is increased. This concurs with earlier observation made by DelCurto *et al*. [30] in a study on utilization of dormant low quality tall grass. The authors found that feeding beef cattle a supplementary diet containing sufficient CP increased both intake and utilization of the low-quality forage. In this study it is assumed that the overall DM intake (from grazing and concentrate supplementation) was higher for animals offered diets with higher CP and ME contents (i.e. MM-MO, MB-CSH, and MB-RP-CSH) indicating that these diets are suitable for fattening cattle compared to CSH.

All animals increased in body weight, this implies that, Tanzania Shorthorn zebu (TSHZ) bulls have ability to gain weight when supplemented. The higher body weight gains which were noted in bulls fed diets MM-MO, MB-CSH and MB-RP-CSH compared to that of animals fed diets RP-CSH and CSH might be due to the sufficient nutrients contained in those diets which were able to meet body requirements. The growth rate of bulls in this study is higher than the growth rate of 0.35 kg/d reported by Mpairwe *et al*. [31] and Msanga and Bee [32] for bulls grazing on natural pasture without supplementation. The growth rate of bulls fed diet MM-MO is higher than the ADG of 0.812 kg/d observed by Mwilawa [9] for TSHZ bulls fed molasses based concentrate and hay under total confinement. The slightly higher ADG might be the result of free choice and selectivity of quality natural pasture during grazing. The growth rate of animals under MM-MO is lower than the ADG of 1.13 kg/d observed by Luziga [33] in Boran crosses supplemented with molasses based concentrate. This difference in ADG is possibly due to breed difference [34]. The growth rates of animals fed diet MB-CSH and MB-RP-CSH in the current study are higher than the ADG of 0.612 and 0.78 kg/d observed by Chamatata [6] and Mawona [8], respectively, on TSHZ cattle supplemented with CSH and CSC. This might be attributed to proper nutrient balance in the experimental diets used in this study. However, the daily weight gains observed in bulls fed diets MB-CSH, RP-CSH, MB-RP-CSH and CSH in this experiment are lower than the values of 1.0 to 1.5 kg/d reported by Mkonyi et al. [3] in TSHZ supplemented with concentrate diet formulated using CSH in

Mwanza region. This might be due to breed difference and different ratios of the concentrate ingredients and possibly due to quality of basal feed (pasture) in the study areas.

The weight gain of the bulls fed the control diet CSH was lower than that of those offered the formulated diets MM-MO, MB-CSH, RP-CSH and MB-RP-CSH because the control diet comprised of cotton seed hulls as the only energy source which had high fibre content and low ME, CP and digestibility. Thus, animals supplemented with the control diet were not able to meet their nutritional requirement for growth. This implies that cotton seed hulls cannot be used as the sole source of energy in fattening diet. Hence, farmers' practice of supplementing grazing cattle with cotton seed hulls alone or in combination with cotton seed cake should be discouraged. Feeds with high protein and energy contents are required in order to promote rumen microbial growth and, hence, improve digestibility of the poor quality roughage. Thus, livestock farmers who fatten cattle should be advised to include maize bran as the source of energy either alone or in combination with rice polishing when formulating supplementary diets. The higher weight gain and growth rate values observed in animals fed MM-MO, MB-CSH, and MB-RP-CSH implies that maize bran, rice polishing and cotton seed cake which are locally available can promote higher growth performance in beef cattle if the diet is properly formulated to meet the nutritional requirements.

The observed lower utilization efficiency (high FCR) for animals fed diet CSH might be due to low organic matter digestibility compared to diets MM-MO, MB-CSH, RP-CSH and MB-RP-CSH. The same reason could be attributed to the higher FCR observed in animals fed diet RP-CSH which contained 37% cotton seed hulls. The substitution of MB with RP might have lowered the digestibility, hence, low utilization by animals on RP-CSH. The reason for the lower digestibility might be the high CF and ADL and low CP contents contributed by higher inclusion levels of RP in RP-CSH and CSH in CSH diet. These findings are similar to those reported by Gadberry *et al*. [35] who found low organic matter digestibility and poor feed efficiency and performance of finishing cows fed rice by-product based diets compared to those fed maize bran based diet. According to McDonald *et al*. [15] high levels of CF and ADL in ruminant rations negatively affect the organic matter digestibility and thus, end up with poor extraction of the required nutrients [22] and [36]. The implication of poor feed utilization is the increased costs of feeding as more feed is required to produce a unit weight gain. In order to improve feed utilization, it is recommended to include not more than 30 to 50% of CSH in beef rations [37], [6] and [38]. Basing on the results of the present study, it can be inferred that the proportions of ingredients used in diets MM-MO, MB-CSH, and MB-RP-CSH were optimal for promoting high weight gain and animals fed these diets had better feed utilization compared to those fed diet RP-CSH and the control diet CSH.

The higher BCS for bulls fed diets MM-MO, MB-CSH and MB-RP-CSH could be attributed to the high weight gain which is the result of animals eating good quality diets. These diets (MM-MO, MB-CSH and MB-RP-CSH) contained adequate nutrients which were readily available to the animals to meet their body requirements compared to diets RP-CSH and CSH. Body condition score showed a positive relationship with weight gain of the experimental bulls. The findings in the present study are consistent with the findings by Bartholomew *et al*. [39] who found a positive linear association in unit change of body condition with weight change for oxen fed different quality diets. This implies that the body condition score of beef cattle can be manipulated basing on the type of diet used. Basing on the results of this study it can be inferred that the formulated diets MM-MO, MB-CSH and MB-RP-CSH had optimal energy and protein contents and animals fed these diets showed better BCS compared to those on diets RP-CSH and CSH.

Gross margin analysis

The observed higher feed cost of diet MM-MO can be attributed to the high costs of the ingredients that were used in feed formulation. Molasses as a by-product of sugarcane processing, is abundantly available near sugar processing industries but is not easily available in many parts of Tanzania, and this triggers high transportation cost. On the other hand, the use of maize meal in diets for fattening cattle is not feasible because of the exorbitant cost as a result of its competitive uses for both human food and monogastric animal feeds.

In the current study it was found that the use of locally available feed ingredients (CSH, RP, and MB) reduced feed costs from 41.4% (MM-MO) to 21.9% (RP-CSH) of the total variable costs. Decrease in feed cost resulting from the use of locally available and cheap feed resources has been observed by Norris *et al*. [40] who reported the decline of 70% in feed costs when high levels of low quality roughage were included in the diets. This implies that the use of CSH, RP, and MB in supplementary fattening diets can reduce cost and increase profit margin of feedlot operations. In the present study, animals supplemented with diet MB-RP-CSH had the lowest cost of feed per body weight gain. This shows that diet MB-RP-CSH is a cheap feed, but yet has high nutritive value and can be used as an alternative fattening supplementary diet to produce a unit weight of meat at a relatively lower cost compared to the other supplementary diets. Although animals provided with the diets MM-MO and MB-CSH had higher total weight gain and ADG than the animals fed diet MB-RP-CSH, the cost of feed consumed per kg live weight gain was also higher for these diets. On the other hand, even if diet RP-CSH had the lowest cost, inefficient utilisation of this diet and, hence, higher feed intake for unit weight gain resulted into the animals fed this feed to have lower gross margin than those fed diet MB-RP-CSH. This means that cheap diets should also be of good quality in order to be efficiently utilized by the animal and meet body requirement for weight gain and, hence increased selling price margin and gross margin. Therefore, this study has revealed that farmers can adopt the use of CSH, RP, and MB as sources of energy and CSC as a source of protein in cattle finishing diets and their proportions in the diet should be like those in diet MB-RP-CSH to improve the efficiency of utilisation of the supplementary diets and ADG at a moderate cost.

V. CONCLUSIONS

- Finishing cattle by supplementing with cotton seed hulls alone or in combination with rice polishing results in animals having higher feed intake, but lower growth rate and weight gain and, hence, lower profit.
- Finishing cattle by supplementing with maize meal and molasses based diet results in higher growth rate and weight gain, but higher feed costs and, hence, lower profit.
- Fishing cattle by supplementing with a diet based on the mixture of maize bran, rice polishing and cotton seed hulls reduces feed costs and at the same time promotes higher growth rate and weight gain, hence, increases profit. Therefore, diet MB-RP-CSH is more profitable than diets MM-MO, MB-CSH, RP-CSH and CSH.
- The mixture of cotton seed hulls, rice polishing and maize bran can substitute maize meal and molasses as sources of energy in cattle fattening diets.

ACKNOWLEDGEMENTS

The authors would like to thank the Tanzania Commission for Science and Technology (COSTECH) for the financial support which enabled to conduct this study. Appreciation is extended to staff at TALIRI - Mabuki and the department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture for their assistance on data collection during the experimental period and laboratory analysis, respectively.

REFERENCES

[1]. Wileman, B. W., Thomson, D. U., Reinhardt, C. D. and Renter, D. G. Analysis of modern technologies used in beef cattle production: Conventional beef production versus nonconventional production using meta-analysis. Journal of Animal Science, 2009. 87: 3418 - 3426.
[2]. Frylinck, L., Strydom, P. E., Webb, E. C. and Du Toit, E. Effect of South African beef production systems on post-mortem muscle energy status and meat quality. Meat Science, 2013. 93: 827-837.
[3]. Mkonyi, P. A., Makungu, L. S., Shigi, K., Kipanga, C., Mihayo, E. J., Palangyo, E. and Lambo, S. The experience of farmers with cotton seed hulls as primary feed material in cattle feedlots in Mwanza and Shinyanga regions of Tanzania. In: Proceedings of the Tanzania Veterinary Association, 2006. AICC, Arusha, Tanzania, 12 - 15 December, 2006.
[4]. Mlote, S. N., Mdoe, N. S. Y., Isinika, A. and Mtenga, L. A. Value addition of beef cattle fattening in the Lake Zone in Tanzania: Challenges and opportunities. Livestock Research for Rural Development, 2012. Volume 24, Article #95. Retrieved May 05, 2022, from http://www.lrrd.org/lrrd24/6/mlot24095.htm.
[5]. Malole, J. L., Kadigi, R. J. M. and Sangeda, A. Z. Costs and benefits of beef cattle fattening schemes in some selected areas of northwest Tanzania. Iranian Journal of Applied Animal Science, 2014. 4(4): 699 -706.
[6]. Chamatata, B. A. Evaluation of cotton seed hulls as dry season roughage source of ruminants. MSc Dissertation, 1996. Sokoine University of Agriculture, Morogoro, Tanzania. 111p.
[7]. Nandonde, S. W. Assessment of the availability of major resources for production of beef in Tanzania. MSc Dissertation, 2008. Sokoine University of Agriculture, Morogoro, Tanzania.111p.
[8]. Mawona, G. F. Performance of beef cattle under different feedlot practices in Mwanza Region. MSc Dissertation, 2010. Sokoine University of Agriculture, Morogoro, Tanzania. 123p.
[9]. Mwilawa, A. J. Effects of breed and diet on performance, carcass characteristics and meat quality of beef cattle. Ph.D. thesis, 2012. Sokoine University of Agriculture, Morogoro, Tanzania.
[10]. NRC (National Research Council). Nutrient requirements of beef cattle: Seventh revised edition, 2000. Washington, DC: The National Academies Press. https://doi.org/10.17226/9791.
[11]. AOAC. Official methods of analysis. Fifteen edition, 2000. Association of Official Analytical Chemists (AOAC), Arlington, Virginia, USA. 1298p.
[12]. Van Soest, P. J., Robertson, J. B. and Lewis, B. A. Methods for dietary fibre, neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 1991. 74(10): 3583-3597.
[13]. Tilley, J. M. A. and Terry, R. A. A two-stage technique for the in vitro digestion of forage crops. Journal of the British Grassland Society, 1963. 18: 104 - 111.
[14]. MAFF (Ministry of Agriculture, Fisheries and Food). Energy allowance and Feeding Systems for ruminants. Technical Bulletin 33, 1975. Ministry of Agriculture Fisheries and Food, HMSO, London. pp 62-67.
[15]. McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., and Morgan, C. A. Animal nutrition. Sixth Edition, 2002. Prentice Hall, Pearson education, London, England. 568p.
[16]. Nicholson, M. J. and Butterworth, M. H. A guide to condition scoring of zebu cattle, 1986. International Livestock Centre for Africa, Addis Ababa, Ethiopia. Retrieved November 05, 2022, from http://www.fastonline.org/CD3WD_40/LSTOCK/002/CattlGen/condsc-zebu/condsc00.htm
[17]. Malope, P., Tsopito, C. M., Aganga, A. A. and Madibela, O. R. Profitability of dry season beef feed-lotting in grain deficit countries: the case of Botswana. Livestock Research for Rural Development, 2007. Volume 19, Article #81. Retrieved May 17, 2022, from https://lrrd.cipav.org.co/lrrd19/6/malo19081.htm
[18]. SAS. Statistical Analysis System. SAS Users Guide, Version 9.1 edition, 2003. SAS Inc., Cary, N.C., USA.

[19]. Cole, N. A. and Hutcheson, D. P. Influence of dietary protein concentrations on performance and nitrogen repletion in stressed calves. Journal of Animal Science, 1990. 68:348 – 349.
[20]. Rutherglen, D. C. Energy and protein requirements of beef cattle. Victoria State Government Agricultural Notes, 1995. AG0374 ISSN 1329-8062.
[21]. Parish, J. A. and Rhinehart, J. D. Energy in beef cattle diets. Mississippi Agricultural and Forestry Experiment Station, 2008. Retrieved January 10, 2022 from http:/www.thebeefsite.com/articles/1653/energy-in-beef-cattle-diets/
[22]. Preston, T. R. and Leng, R. A. Matching ruminant production systems with available resources in the tropics and subtropics. Penambul Books, Armidale, chapter 3, 1987. Retrieved August 20, 2021 from https://www.cipav.org.co/PandL/chapter3.htm
[23]. Tolera, A. and Sundstøl, F. Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stages of maturity. 1. Feed intake, digestibility and body weight change. Animal Feed Science Technology, 2000. 85: 239 - 257.
[24]. Kossila, V. Global review of the potential use of crop residues as animal feed. In: T. R. Preston, V. L. Kossila, J. Goodwin and S. B. Reed (eds), Better utilization of crop residues and by-products in animal feeding. 1. State of knowledge. FAO Animal Production and Health Paper 50, 1985. Food and Agriculture Organization of the United Nations, Rome. pp. 1-13.
[25]. Asimwe, L., Kimambo, A.E., Laswai, G.H., and Mushi, D. Growth performance and carcass characteristics of Tanzania Shorthorn Zebu cattle finished on molasses or maize grain with rice or maize by-products. Livestock Science, 2015. 182: 112 – 117. DOI:10.1016/j.livsci.2015.11.001
[26]. Emmans, G. C. A method to predict the food intake of domestic animals from birth to maturity as a function of time. Journal of Theoretical Biology, 1997. 186: 189 - 199.
[27]. Morales, J. L., Vanhorn, H. H. and Moore, J. E. Dietary interaction of cane molasses with source of roughage: Intake and lactation effects. Journal of Dairy Science, 1989. 72:2331 - 2338.
[28]. Moore, J. A., Poore, M. H. and Swingle, R. S. Influence of roughage source on kinetics of digestion and passage and on calculated extents of ruminal digestion in beef steers fed 65% concentrate diets. Journal of Animal Science, 1990. 68:3412 - 3420.
[29]. Rowe, J. B., Tudor, G. D., Dixon, R. M. and Egan, A. R. Cereal or legume grains as supplements for animals grazing stubble or dry pasture. In: Recent Advances in Animal Nutrition in Australia (Edited by Farrell D J), 1991. University of New England, Armidale. pp 72-82. Retrieved August 20, 2021 from http://www.livestocklibrary.com.au/bitstream/handle/1234/19673/91_072.pdf.
[30]. DelCurto, T., Cochran, R. C., Harman, D. L., Beharka, A. A., Jacques, K. A., Towne, G. and Vanzant, E. S. Supplementation of dormant tallgrass-prairie forage: 1. Influence of varying supplemental protein and (or) energy levels on forage utilization characteristics of beef steers in confinement. Journal of Animal Science, 1990. 68:515 - 531.
[31]. Mpairwe, D. R., Katongole, C., Bareeba, F. B., Mukasa-Mugerwa, E., and Ebong, C. Effect of plane of nutrition on growth performance and carcass characteristics of growing Ankole, N'ganda, and crossbred (Friesian x Ankole) bulls and their potential for beef cattle fattening in Uganda. In: Proceedings of the 30th Tanzania Society of Animal Production (TSAP) Scientific conference, 2003. 4H centre, Tanga, Tanzania, 28 -30th October 2003.
[32]. Msanga, N. Y. and Bee, J. K. A. The performance of Friesian x Boran bulls managed extensively under agropastoralism with indigenous Tanzanian zebu. Livestock Research for Rural Development, 2006. Volume 18, Article #20. Retrieved October 30, 2021, from http://www.lrrd.org/lrrd18/2/msan18020.htm
[33]. Luziga, A. Mtibwa Feedlot Project. Annual research report from July 2004 to September 2005, 2005. Ministry of Livestock and Fisheries Development, Dar es Salaam, Tanzania. 25p.
[34]. Asizua, D., Mpairwe, D., Kabi, K., Mutetikka, D. and Madsen, J. Growth and slaughter characteristics of Ankole cattle and its Boran and Friesian crossbreds. South African Journal of Animal Science, 2009. 39 (5): 81 -85.
[35]. Gadberry, M. S., Beck, P. A. and Gunter, S. A. Rice milling coproducts as feedstuffs for beef cattle. The Professional Animal Scientist, 2007. 23: 309 - 315.
[36]. Sanon, H. O., Kabore-Zoungrana, C. and Ledin, I. Nutritive value and voluntary feed intake by ruminants in the Sahelian zone of West Africa. Animal Feed Science and Technology, 2007. 20: 50 - 60.
[37]. Garleb, K. A., Fahey, G. C., Lewis, S. M., Kerley, M. S. and Montgomery, L. Chemical composition and digestibility of fiber fractions of certain by-product feedstuffs fed to ruminants. Journal of Animal Science, 1988. 66: 2650 - 2662.
[38]. Reddy, G. V. N. and Reddy, M. R. Nutrient utilization and rumen fermentation pattern of cotton seed hulls based complete diets in crossbred bulls. Indian Journal of Animal Nutrition, 1999. 16 (1): 6 - 11.
[39]. Bartholomew, P. W., Ly, R., Doumbia, M., Khibe, T., Kone, N'g., Traore, B. and Ba, S. Agro-industrial by-products, cowpea residues and urea-treatment of hay for supplementary dry season feeding of mature zebu oxen in Mali. Livestock Research for Rural Development, 2003. Volume 15, Article #15. Retrieved November 30, 2021, from https://www.lrrd.cipav.org.co/lrrd15/2/bart152.htm
[40]. Norris, D., Macala, J., Makore, J. and Mosimanyana, B. Feedlot performance of various breed groups of cattle fed low to high levels of roughage. Livestock Research for Rural Development, 2002. Volume 14, Article #59. Retrieved March 01, 2022, from http://www.lrrd.org/lrrd14/6/norr146.htm