CARCASS AND MEAT QUALITY CHARACTERISTICS OF INDIGENOUS CATTLE IN TANZANIA

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ABSTRACT

Seventy two Tanzania indigenous cattle (36 Boran steers; 2-3 years old; initial liveweight 225 kg and 36 Tanzania Short Horn Zebu (TSHZ); 3-4 years old; initial liveweight 117 kg) were randomly allocated to three dietary treatments to study the effects of breed, diet and ageing time on carcass and meat quality characteristics. Animals were fed three different diets: grazing alone (Diet 1: control), control + 50 % *ad libitum* concentrate intake (Diet 2) and *ad libitum* hay + *ad libitum* concentrate intake (Diet 3). The concentrate contained 126 g CP and 13 MJ ME per kg DM. The steers were fattened for 90 days, slaughtered, and carcass and meat quality assessed. Boran had heavier ($P<0.05$) empty body weight, carcass weight and greater rib area than TSHZ (242 vs. 192 kg; 132 vs. 108 kg and 56 vs. 47 cm^2). Animals fed diet 3 had higher ($P<0.05$) dressing percentage, carcass fat thickness, conformation score and normal meat colour score (54%; 2 cm; 12; 2.9) followed by Diet 2 (51%; 0.9 cm; 9; 3.7 and lastly Diet 1 (47%; 0.6 cm; 7; 4.4). In addition, *longissimus dorsi* (LD) muscle from animals fed Diet 3 had the lowest ($P<0.05$) shear force (45 N) indicating very tender meat whereas LD from animals fed diet 1 had the highest value (60 N) indicating less tender meat. Increasing post-mortem storage time from 2 up to 20 days decreased ($P<0.05$) shear force by 65%. It is concluded that both Boran and TSHZ cattle obtained acceptable range of meat quality values and that tender meat can be produced from indigenous cattle through feedlot finishing and post-mortem storage at refrigerated temperatures.

Key words: *cattle, diets, ageing time, feedlot, carcass and meat parameters, toughness,*

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INTRODUCTION

In Tanzania most of the beef consumed comes from indigenous cattle (80% from agro pastoral and 14% from pastoral production system) (Njombe and Msanga, 2009). The beef produced is mainly from old worn out animals finished from poor quality pasture (Luziga, 2005). The commercial value of beef carcass depends ultimately on their size, structure and composition. The main structural characteristics of commercial importance are weight, proportion of main tissues (muscle, fat and bone) and distribution of these tissues through the carcass, muscle thickness, chemical composition and visual appearance of the meat. Generally, this information together with the meat quality or taste of the indigenous cattle in Tanzania as well as reports on consumers preference on beef are lacking. There has been increasing demand for quality beef in the country and this has led to importation of the same from foreign countries (Kinunda-Rutashobya, 2003; Madsen, 2005).

The question "meat quality?" has conjured up many definitions in the scientific literature, including "fitness for use, the ability to satisfy a need, meeting specified demands, the degree of excellence at a reasonable price, and the totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs" (Gray *et al*. 1996). Quality can be understood as the relationship between the real and the desired properties of a product or as a measure of the satisfaction of the consumer (Ingr, 1989). Meat quality is the measure of traits that are sought and valued by the consumer (Andersen *et al.* 2005; Mushi *et al* 2009). If it is to be used in a relatively intact form, such as steaks or roasts, meat is considered to be of high quality if it is attractive in both raw and cooked appearance, appetizing, nutritious, wholesome and palatable in its final prepared state. If it is to be utilized in any of a wide variety of processed meat products, its quality is largely determined by its many functional roles.

The assessment of quality is thus strongly influenced by proportion of the tissues among carcass of similar weight; the percentage formed by each tissue varies considerably depending on breed type and growth rate. The proportional of lean meat in the carcass is of major importance since this is the prime determinant of yield and commercial value. Leanness is the criterion by which most consumers' judge quality and value for money. Taken as a generalized ideal, the best carcass should have an optimum level of fatness and minimum bone. In addition tenderness is considered to be one of the most important eating quality attributes, which influences the consumers overall judgment and perception of beef

(Dransfield *et al.* 1998 cited by Christensen *et al* 2007; Steen *et al*. 1997 cited by Mushi *et al*. 2009). Post-mortem storage has been the most commonly applied industrial technique used to improve tenderness in beef (Sentandrew *et al.* 2002; Jayasooriya *et al*. 2007).

In several trials an improvement of carcass quality or killing out percentage as a result of supplementation and feedlot practices has been noted (Owens and Gardener, 1999; Mertz and Sørensen, 2005). In this study slaughter and carcass characteristics have been evaluated from two indigenous cattle and three different diets. It has not been studied yet on how tenderness is affected during post mortem storage for indigenous breed (Boran and TSHZ), therefore in this study we have investigated tenderness using Warner-Bratzler shear force (WBSF) (Lepetit and Culioli 1992 cited by Mette *et al*. 2007).

MATERIAL AND METHODS

Experimental design and treatments

A total of seventy two (72) steers, thirty six (36) Boran and 36 TSHZ were used The age range for the two genotypes were 2 – 3 and 3 – 4 years old with average initial weights of 225 kg and 117 kg for Boran and TSHZ respectively. A 2 X 3 factorial experiment in a completely randomized design (CRD) with 3 repeated measurements on meat quality parameters is used. The main factors studied were the two breeds (TSHZ and Boran) and three dietary treatments and with three ageing times as repeated measurements for meat parameters. The dietary treatments used were as follows: Diet1 (Grazc00) = grazing alone as control, Diet 2 (Grazc50) = Grazc00 + 50 % *ad libitum* concentrate intake and Diet 3 (Hyc100) = *ad libitum* hay + *ad libitum* concentrate intake. The three ageing time were 2, 10 and 20 days. Individual animal was considered as an experimental unit in all killing out characteristics and meat quality data analysis.

Animals and management

Steers of the TSHZ Gogo strain were purchased from Kizota auction Markets, and Boran steers were purchased from Kongwa ranch, both in Dodoma region, Tanzania. On Arrival at experimental site at Kongwa ranch, animals were weighed and received prophylactic treatment such as vaccination against *Contagious Bovine pleuropneumonia* (CBPP). About 11 TSHZ steers which appeared not to be fully castrated, were re-castrated using Burrdizo. Animals were treated against external parasites after every ten days. Grazing animals were

treated through dipping in a common dip containing Bayticol EC 6% with Dilution of 1000 ml per 1500 litres of water while animals kept under feedlot pens were not tracked to the dip instead they were hand sprayed using Paranex 100 EC 6%. Dilution was 10ml of PARANEX per 20 litres of water. Deworming was done on arrival and in the mid of the respective experiment where *Tramazole: Albendazole* 10% W/V drench was used to protect against round, tape and fluke worms. Other diseases such as fever were treated as they occurred mainly using *Oxytetracycline* 10% (250 mls to 100 mg/ml) and *Oxytetracycline* HCL injection. The animals were monitored daily for their behaviour and health status.

Following the allocation of the animals in their respective treatments and pens, animals had 17 days for familiarization to the feeds and pens. During familiarization, animals in Grazc00 were grazing; animals in Grazc50 were grazing and later in the evening were taken to respective pens and concentrate supplementation depending on the amount consumed by animals in Hyc100 in that day. All animals in Hyc100 were given *ad libitum* hay and proportionate concentrate supplementation was provided until *ad libitum* concentrate intake was reached. Data collection started after the 17 days and lasted for 90 days.

Slaughtering animals

Following fattening period of 90 days all the animals were taken for slaughter at Dodoma slaughter house. The animals were transported for about 1 hour on a track perpendicular to the direction of travel and animals did not lie down during transit. On arrival at the abattoir the animals were inspected by a veterinary officer and kept in the lairage in isolation from other non experimental animals. From the time of transporting the animals from feedlot to the abattoir they were neither fed nor given water. The animals were fasted for about 13 - 17 hours prior to slaughter. At slaughter, animals were stunned using electrical stunner which is the normal practice at the abattoir and immediately suspended in the Achilles tendon. The animals were slaughtered on the neck using very sharp knives. As a matter of rule the animals were slaughtered by authorized Muslim personnel for the meat to be Halal. As a normal procedure at the abattoir no electrical stimulation was performed. Thereafter the suspended animals were skinned and dressed.

Data collected

Non carcass and carcass measurements

Non carcass measurements included weighing of the internal organs (kidney and fat), pluck, and the fat surrounding the kidneys was removed and weighed. The mesenteric fat (fat surrounding the gastro-intestinal tract (GIT) was also removed and weighed. Fat and kidney weights were measured using a portable digital weighing balance. The weights of full gut and empty gut were taken using a sorter balance. Following the removal of internal organs, the dressed carcass was separated into left and right carcass by cutting using a meat saw available at the abattoir. Both left and right hot carcass weight (HCW) were taken using automatic electrical balance available at the abattoir. The total HCW was taken as the sum of the left and right hot carcass weight. Dressing percentage and empty gut full weight also were derived. Morphological carcass body measurements were taken using measuring tapes, slide ruler and vernier calliper. The following measurements were taken: carcass length, internal depth of chest, limb length and limb width (thickness) (inner side of carcass) all these were taken within the first one hour post-mortem.

Carcasses were classified using a EUROP classification system for cattle (Borggard *et al*. 1996 cited by Madsen, 2002). Carcasses were classified for conformation (scale from E = excellent to P = poor), fatness (scale from 1 = none or low fat cover to 5 = entire carcass covered with fat) and meat colour (scale from 1 = extra light to 5 = dark/ yellow). Each of the five EUROP classes for conformation was divided into three subclasses: -, 0, or + to form 15 grades. High value for conformation class indicates a carcass with well to excellent rounded muscles. High value for fat class indicates a carcass with a high degree of external fat (subcutaneous) while high value of meat colour shows the meat to have dark/ yellow colour.

The carcass compositions were estimated from the 6^{th} rib sample joint of the left side of the carcass according to Robelin and Geay, (1975) method. The carcass composition was obtained by the separation of the subcutaneous and intramuscular fat, meat, bones and other tissues (e.g. ligaments, tendons). The joint was weighed (kg) and then dissected into fat, lean (muscle) and bone tissue. Fat comprised intramuscular and subcutaneous tissues. The weights of the components were then expressed as percentage of the joint weight to obtain the percentage distribution of the carcass composition. Longissimus dorsi (LD) area from the left side of the carcass that remained during removal of the 6^{th} rib, was traced over the 5^{th} rib.

Meat quality parameters

Measurement of carcass temperature and pH was taken at the 10th rib of the right side of the carcass in the *Longissimus dorsi* (LD) muscle. The readings were performed at 45 minutes, 6, 24 and 48 h post-mortem (pm). The temperature was measured by insertion of the thermometer pointer to the muscle. The temperatures were recorded using FUNKUTION Digital stegetermometer (Digital thermometer) meat thermometer.

The rate of the pH fall in the LD was measured by inserting a penetrating electrode (Mettler Toledo) on muscle at 45 minutes, 6, 24 and 48 h pm using a portable pH-meter (Knick-portamess 911, Germany). Using a scalpel, fat was cut through and the probe was inserted into the muscle at a slight downward angle and twisted gently back and fourth until when the pH was stable then the readings were taken. The pH meter was calibrated at room temperature of 28^{o}C in buffer solution for pH 7 and pH 4. The pH meter was again calibrated at 4^{o}C of buffer solution for measuring pH of cold carcass at 24 and 48 h pm (the recorded pH at 48 h were the ultimate pH). The calibrations of temperature were as the internal temperature of the LD as per Rosenvold *et al.* (2002). Each carcass was kept at room temperature up to 10 h pm and then transferred to a cold room where the temperatures were kept between 0 – 4 ^{o}C. The temperature and pH readings at 45 minutes and 6 h pm were performed at room temperature while the readings at 24 and 48 h pm were performed while the carcasses were in the cold (chiller) room.

The muscle LD from the 7th to the 13th rib of the right side of carcass was removed 48 hrs post-mortem. From each rear end of the muscle LD, a sample (2 cm thick or equivalent of 120g) was cut and labelled for drip loss determination according to Honikel (1998) and Otto *et al*, (2004). The remaining piece was used for assessment of shear force. Three pieces (7 cm long) were cut along the fibre direction from the remaining *Longissimus dorsi* (LD) muscles. These three pieces were cut for measurement of meat toughness. The samples were aged for 2, 10 and 20 days pm in a chilling room (0 - 4^{o}C). Following the completion of each storage time, each sample was taken from the chilling room and transferred to the freezer (-20 ^{o}C) until analysis.

Meat toughness was determined using the Warner-Bratzler Shear Force (WBSF) machine (Zwick/Roell Z2.5, Germany). The meat pieces to be assessed for shear force were thawed

for 12 h at refrigerated temperature (4 ^{o}C) and weighed. Each sample was opened, wiped with clean tissue paper, weighed and re-sealed with vacuum pack machine. The samples were then heated at 75 ^{o}C for 1 h in a circulating water bath. Cooking was arrested by placing samples in cold tap water which had been flowing for about 2 hrs. Cooled samples were opened and muscle juice inside was removed. The samples were wiped with clean tissue paper and then weighed and the weight was recorded to calculate the cooking loss. Four rectangular shaped blocks (1 x 1 x 5 cm) were cut and each block was sheared three times perpendicular to the muscle fibre direction with rectangular-shaped shear blade (angled at 60^{o}) attached to Zwick/Roell (22.5 Germany) instrument. The average of 12 shear values represented the WBSF force value for a sample of LD from each treatment. The Zwick was set with 1 kN load cell, with a crosshead speed of 200mm/min. The maximum load required to shear through the sample (WB peak force) was determined.

Statistical analysis

Statistical evaluation of carcass and non carcass characteristics was performed using General Linear Model (GLM) and meat quality data was performed using the Mixed Model procedures of Statistical Analysis System (SAS, 9.2, Institute Inc., NC, USA). The main effect of breed, diet and ageing time was determined. The significant differences between treatments were compared using the option of PDIFF.

RESULTS

Table 1 gives the least square means of the effect of breed and diet on killing out characteristics of slaughtered steers. The effect of breed and diet on final body weight (FBW) was significant different ($P<0.05$). As expected Boran steers had higher FBW (258 vs. 209 kg) than TSHZ. Steers fed Hyc100 had high FBW (283 kg) followed by Grazc50 (229 kg). No significant difference ($P>0.05$) was observed on weight of gut content between the breeds, although Boran showed slightly heavier weight than TSHZ (17 kg Boran vs. 16 kg TSHZ). Significant difference on gut content was observed between diets ($P<0.05$) where Grazc00 had the heaviest gut content weight (18 kg) followed by Grazc50 (16 kg). Breed and diet showed differences ($P<0.05$) in empty body weight and hot carcass weight. Boran steers had higher empty body weight (242 vs. 192 kg) and hot carcass weight (132 vs. 108 kg) than TSHZ. Steers fed Hyc100 had higher empty body weight (269 kg) and hot carcass weight (154 kg) followed by steers fed on Grac50 with empty body weight of 208 kg and hot carcass weight of 115 kg.

Dressing percentage (DP) was significantly affected by diets ($P<0.05$). Steers on Hyc100 dressed high (54 %) followed by steers on Grazc50 (51 %). Steers fed Grazc00 were losing weight hence had the poorest DP (47%). On individual treatment, both Boran and TSHZ fed on Hyc100 had the highest dressing percentage (55 and 54 %) although the difference was insignificant ($P>0.05$) (Figure 1). Also Boran and TSHZ fed Grazc00 performed poorly (46 and 48 %) and the difference was insignificant ($P>0.05$). Dressing percentage increased with increase in concentrate supplementation in the diet. Both Boran and TSHZ dressed similarly ($P>0.05$). Breed difference was insignificant ($P>0.05$) and in all the diets Boran had higher gut fill as percentage of final body weight. Diet affected the gut fill as percentage of final body weight ($P<0.0001$) and decreased with increase in concentrate in the diet.

Breed and diets showed differences ($P<0.05$) in all assessed non-carcass components except kidney weight which was not influenced by breed. Boran steers had heavier pluck weight (12.2 vs. 10.8 kg), mesenteric fat (4.7 vs. 4.0 kg) and total fat (6.4 vs. 5.6 kg) than TSHZ. The weights of non-carcass components increased with increase in concentrate offer in the diets. Breed difference ($P<0.05$) was observed in gut fill as percentage of FBW and EBW. Gut weight as a percentage of FBW was higher in TSHZ (14 vs. 13 %) than Boran steers (Figure 2) while steers fed on Hyc100 had smallest ($P<0.05$) gut fill as percentage of FBW (11 %).

Table 1: *Least*-squares mean for the effect of breed and diet on killing out characteristics, non carcass components and their proportions

Parameter	Breed				Dietary treatment				
	Boran	TSHZ	SEM	*P - Value*	Grazc00	Grazc50	Hyc100	SEM	*P - Value*
Weights (kg)									
Final bodyweight	258 [a]	209[b]	1.2	<.0001	186[c]	229[b]	283 [a]	3.3	<.0001
Weight gut content	17	16	1.1	0.7797	18 [a]	16 [ab]	15[b]	0.8	0.0397
Empty body weight	242 [a]	192 [b]	6.2	<.0001	174 [c]	208 [b]	269 [a]	4.2	<.0001
Hot carcass weight	132 [a]	108[b]	2.7	<.0001	90[c]	115[b]	154[a]	3.2	<.0001
Dressing percentage (%)	51	51	0.9	0.6366	47[b]	51[ab]	54 [a]	1.1	<.0001
Non carcass components (kg)									
Pluck	12.2[a]	10.8[b]	0.2	<.0001	9.1[c]	11.0[b]	14.2 [a]	0.3	<.0001
Kidney	0.6	0.5	0.02	0.4160	0.5[b]	0.5[b]	0.6 [a]	0.02	0.0016
Mesenteric fat	4.7 [a]	4.0[b]	0.2	0.0369	1.7[c]	3.6[b]	7.9 [a]	0.3	<.0001
Total fat trimmed	6.4 [a]	5.6[b]	0.3	0.0462	2.3[c]	4.9[b]	10.9 [a]	0.4	<.0001
Gut full % FBW	13[b]	14[a]	0.5	<.0001	16 [a]	13[b]	11[c]	0.3	<.0001

[abc]Least square means with different superscripts are significantly different (P<0.05). Probability values (*P*-value); Grazc00 =grazing alone as control; Grazc50= grazing + 50 % *ad libitum* concentrate intake; and Hyc100 = *ad libitum* hay + *ad libitum* concentrate intake; Standard error of mean (SEM); Tanzania shorthorn zebu (TSHZ) and Final body weight (FBW)

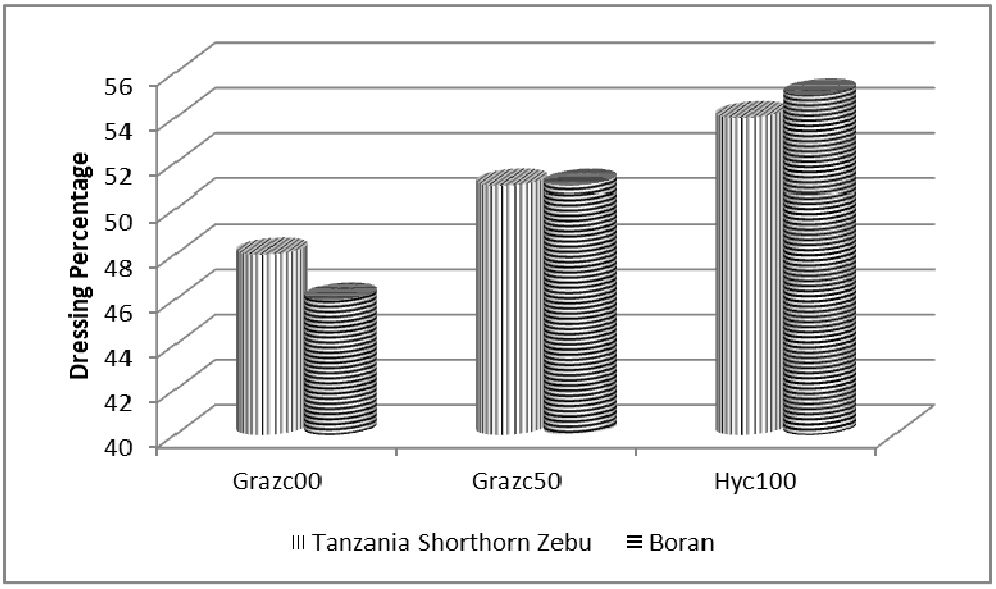

Figure 1: Illustration on the effect of breed and diet on individual treatment on dressing percentage of Boran and Tanzania shorthorn zebu steers.

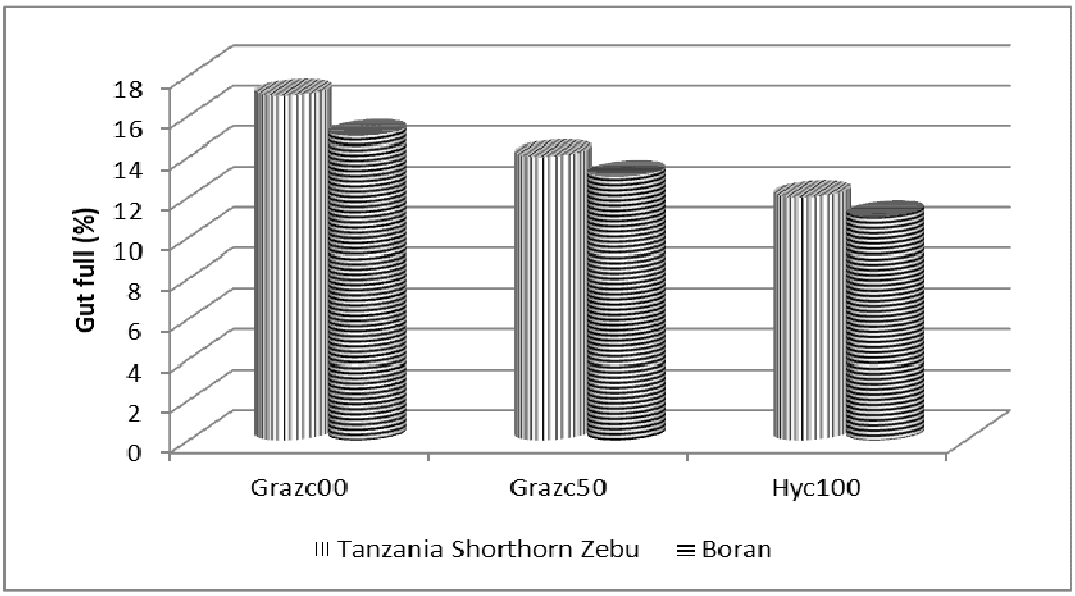

Figure 2: Illustration of the individual treatment of the effect of breed and diet on gut full as percentage of the final body weight of Boran and Tanzania shorthorn zebu steers.

Table 2 gives the *Least*-squares means for the effect of breed and diet on carcass linear measurements and EUROP carcass classification. There was breed differences ($P<0.05$) on carcass length, limb circumference and rib area. In all the parameters, Boran had longer carcass length (109 vs. 101 cm), bigger limb circumference (67 vs. 59 cm) and larger rib area (56 vs. 47 cm^2). Diet affected all the parameters significantly ($P<0.05$) and in all the parameters observed, the values increased with increase in concentrate supplementation in the diets.

Breed difference ($P<0.05$) was observed on carcass conformation and Boran carcasses scored higher (10= U- (slightly very good muscle development) vs. 9= R+ (Good muscle development)) than TSHZ. The diet affected carcass conformation, fatness and meat colour significantly ($P<0.05$). On average carcasses from Hyc100 scored high on carcass conformation (12= U+ very good muscle development) and CF (4 = abundant fat cover) than the other diets whereas carcasses from the same diet scored low on MC (3=normal colour) in comparison Grazc50 (CC = 9; CF = 3 and MC= 4) and Grazc00 (CC = 7; CF=2 and MC = 4). As expected, animals on grazing had slight fat cover and dark meat colour. Carcass conformation and fat scores increased as the concentrate supplementation increased in the diet whereas the scores on meat colour decreased.

Table 2: *Least*-squares mean for the effect of breed and diet on carcass linear measurements and EUROP carcass classification

Parameter	Breed				Dietary treatment				
	Boran	TSHZ	SEM	*P - Value*	Grazc00	Grazc50	Hyc100	SEM	*P - Value*
Carcass measurements (cm)									
Carcass length	109 [a]	101 [b]	1.1	0.0032	103 [b]	104 [b]	108 [a]	1.0	0.0064
Carcass chest length	54 [a]	49 [b]	1.4	0.0775	49 [b]	51 [ab]	54 [a]	1.0	0.0203
Limb circumference	67 [a]	59 [b]	1.4	0.0043	58 [c]	62 [b]	70 [a]	1.0	<.0001
Fat thickness	1.1	1.2	0.2	0.7267	0.6 [b]	0.9 [b]	1.9 [a]	0.1	<.0001
Back fat	3.1	2.4	0.3	0.5644	1.7 [c]	2.9 [b]	4.5 [a]	0.2	<.0001
Rib Area (cm^2)	56 [a]	47 [b]	1.6	0.0003	46 [b]	53 [a]	57 [a]	2.0	<.0001
EUROP Classification (score)									
Carcass conformation	9.5 [a]	8.8 [b]	0.2	0.0341	6.5 [c]	8.9 [b]	12.1 [a]	0.2	<.0001
Carcass fatness	2.7	2.8	0.1	0.5272	1.8 [c]	2.8 [b]	3.8 [a]	0.1	<.0001
Carcass meat colour	3.6	3.7	0.1	0.3914	4.4 [a]	3.7 [b]	2.9 [c]	0.1	<.0001

[abc]Least square means with different superscripts are significantly different (P<0.05). Probability values (*P*-value); Grazc00 =grazing alone as control; Grazc50= grazing + 50 % *ad libitum* concentrate intake; Hyc100 = (*ad libitum* hay + *ad libitum* concentrate intake); Standard error of mean (SEM) and Tanzania shorthorn zebu (TSHZ).

Slettet: [de]

Table 3 gives the effect of breed and diet on carcass physical composition of Boran and TSHZ steers. Breed showed differences ($P<0.05$) on rib weight and bone but it was insignificant ($P>0.05$) on lean and fat composition. Boran carcasses had heavier weights of rib (2.1 vs. 1.9 kg) and bone (0.4 vs. 0.3 kg) than TSHZ. Diets showed significant differences ($P<0.05$) on rib, lean and fat. The trend showed increased weights rib, lean and fat from Grazc00 to Grazc50 and finally to Hyc100. As expected, diets had no effect ($P>0.05$) on bone weight during fattening, although all other parameters increased with increase in concentrate offer. Carcasses from Hyc100 had high weight of lean and fat proportion than from Grazc50 and Grazc00 but the difference in proportions was insignificant ($P>0.05$).

Diets showed differences ($P<0.05$) on percentage of fat in the carcasses. Diets on Hyc100 showed higher ($P<0.05$) percentage of fat (21%) in carcasses followed by Grazc50 (13%). Similarly when ratios were computed, there was no difference ($P>0.05$) on the ratios, although TSHZ showed higher values in all the ratios. Diets affected all the ratios Lean:fat, Lean:bone and fat to bone.

Table 3: ***Least*-squares means for the effect of breed and diet on carcass composition from the 6th rib**

Parameter	Breed				Dietary treatment				
	Boran	TSHZ	SEM	*P – Value*	Grazc00	Grazc50	Hyc100	SEM	*P - Value*
6th Rib Carcass Composition (kg)									
Rib	2.1	1.9	0.1	0.0335	1.4[c]	1.9[b]	2.7[a]	0.1	<.0001
Lean	1.4	1.3	0.1	0.2621	1.0[c]	1.3[b]	1.8[a]	0.1	<.0001
Fat	0.3	0.3	0.01	0.8892	0.1[c]	0.3[b]	0.6[a]	0.02	<.0001
Bone	0.4	0.3	0.01	0.0001	0.3	0.4	0.4	0.01	0.1203
% Carcass composition 6th Rib									
Lean	66	67	1.1	0.5668	67	67	64	1.4	0.2712
Fat	14	14	0.9	0.9538	9[c]	13[b]	21[a]	1.1	<.0001
Bone	20	19	0.6	0.2655	24[a]	19[b]	15[c]	0.7	<.0001
Ratios of 6th Rib components									
Lean:fat	6.1	6.8	0.6	0.4009	10[a]	6.1[b]	3.3[c]	0.7	<.0001
Lean:bone	3.5	4.2	0.3	0.0907	2.9[c]	3.7[b]	4.9[a]	0.3	0.0002
Fat:Bone	0.8	0.9	0.1	0.1888	0.4[b]	0.7[b]	1.5[a]	0.1	<.0001

[abc]*Least square means* with different superscripts are significantly different (P<0.05). Probability values (*P*-value); Standard error of mean (SEM); Grazc00 =grazing alone as control; Grazc50= grazing + 50 % *ad libitum* concentrate intake and Hyc100 = (*ad libitum* hay + *ad libitum* concentrate intake); TSHZ = Tanzania shorthorn zebu.

Table 4 shows temperature readings and pH obtained at 45 min, 6 h, 24 h and 48 h post-mortem (pm) measured in LD as affected by breed (Boran or TSHZ) and diet. Temperature was affected ($P<0.05$) by breed at 45 minutes and 6 h pm. On average temperature was higher in LD from Boran than TSHZ. No difference in temperature between breeds ($P>0.05$) appeared at 24 and 48 h pm. Temperature was also affected ($P<0.05$) by finishing diets at 45 min, 6 h and 24 h pm. LD from Boran steers fed Hyc100 had higher temperature values (40.3, 30.7 and 3.7 ^{o}C respectively) at 45 min, 6 and 24 h pm compared to Grazc00 (37.8, 25.5 and 2.8 ^{o}C respectively). No breed effect ($P>0.05$) on pH of LD was found. In general, pH decreased from around 6.45 to 5.60 from 45 min to 48 h pm. Finishing diets affected ($P<0.05$) pH at 24 h, and 48 h pm and all the values at ultimate pH 48 h pm were within the acceptable range.

Table 4: *Least*-squares means of temperature and pH in bovine *longissimus dorsi* muscle as affected by breed and diet.

Temperature Readings	Breed				Dietary treatment				
	Boran	TSHZ	SEM	*P - Value*	Grazc00	Grazc50	Hyc100	SEM	*P - Value*
Temperature (°C)									
45min	39.2[a]	38.8[b]	0.2	0.0494	37.8 [c]	38.9[b]	40.3 [a]	0.2	<.0001
6 h	27.9[a]	27.4[b]	0.1	0.0206	25.5 [c]	27.5[b]	30.7 [a]	0.2	<.0001
24 h	3.3	3.2	0.1	0.4983	2.8[b]	3.3[ab]	3.7[ab]	0.2	0.0036
48 h	2.5	2.3	0.2	0.3148	2.2	2.5	2.6	0.1	0.0781
pH readings									
45min	6.49	6.41	0.01	0.1043	6.43	6.43	6.46	0.04	0.8403
6 h	5.93	5.87	0.04	0.4477	5.97	5.91	5.84	0.05	0.1529
24 h	5.58	5.59	0.01	0.8683	5.58	5.57	5.63	0.02	0.0153
48 h	5.59	5.60	0.01	0.3863	5.58 [b]	5.54[c]	5.63[a]	0.01	0.0001

[abc]*Least squares means* with different superscripts are significantly different (P<0.05). Probability values (*P*-value); Grazc00 =grazing alone as control; Grazc50= grazing + 50 % *ad libitum* concentrate intake; Hyc100 = (*ad libitum* hay + 100 % of the *ad libitum* concentrate intake) and Standard error of mean (SEM); TSHZ = Tanzania shorthorn zebu.

Table 5 shows the least squares means of drip loss, thawing loss, cooking loss and shear force in bovine LD as affected by breed and diet. Drip loss and thawing loss was not affected ($P>0.05$) by breed or diet. Cooking loss of bovine LD was not affected by breed ($P>0.05$) but decreased from 24 to 17% ($P<0.05$) with increasing amount of concentrate in the diet. Shear force of bovine LD muscles was not affected ($P>0.05$) by breed. Finishing diet, however, affected shear force markedly ($P<0.05$). As expected animals on Grazc00 had the highest shear force values (60 N). Increasing concentration of concentrate in the diet decreased ($P<0.05$) shear force.

Table 6 gives the results of the ageing effect on thawing loss, cooking loss and shear force. Post-mortem ageing up to 20 days after slaughter reduced ($P<0.05$) thawing loss but did not affect ($P>0.05$) cooking loss. Increasing storage time from 2 to 10 days post-mortem reduced thawing loss by 37 %. No significant change in thawing loss was observed from 10 to 20 days post-mortem. Storage of bovine LD muscle up to 20 days post-mortem at refrigerated temperatures decreased shear force. In general, shear force decreased by 25 % from 2 -10 days ageing and by 21 % from 10 – 20 days ageing.

Table 5: *Least* squares means of percentage drip loss, thawing loss, cooking loss and shear force (N) in bovine *longissimus dorsi* as affected by breed and diet.

Parameter	Breed				Dietary treatment				
	Boran	TSHZ	SEM	*P - Value*	Grazc00	Grazc50	Hyc100	SEM	*P - Value*
Drip loss (%)	3.7	3.1	0.3	0.1359	3.8	3.2	3.1	0.3	0.3397
Thawing loss (%)	5.6	5.2	0.5	0.5344	5.1	5.1	4.9	0.6	0.3291
Cooking loss (%)	19.5	21.4	0.9	0.1497	24.0 ^{a}	20.8 ^{b}	16.8 ^{c}	1.1	<.0001
Shear force (N)	51.3	52.1	1.4	0.6873	59.5^{a}	50.9^{b}	44.7^{c}	1.7	<.0001

^{abc} *Least squares means* with different superscripts in the same row are significantly different (P<0.05). Probability values (*P*-value); Standard error of mean (SEM); Grazc00 =grazing alone as control; Grazc50= grazing + 50 % *ad libitum* concentrate intake and Hyc100 = (*ad libitum* hay + 100 % of the *ad libitum* concentrate intake); TSHZ = Tanzania shorthorn zebu.

Table 6: *Least* squares means of percentage thawing loss, cooking loss and shear force in bovine longissimus dorsi as affected by post-mortem storage

Parameter	Storage time (days post-mortem)			SEM	*P-Value*
	2	**10**	**20**		
Thawing loss (%)	7.0[a]	4.4[b]	4.7[b]	0.5	0.0005
Cooking loss (%)	19.5	21.4	20.5	1.0	0.4216
Shear force (N)	66.1[a]	49.6[b]	39.4[c]	1.5	<.0001

[abc]*Within rows, least squares means* with different superscripts are significantly different (P<0.05). Probability values (*P*-value); Standard error of mean (SEM).

DISCUSSIONS

Carcass and non-carcass characteristics

Significant differences due to breed and diets were observed in FBW, empty body weight (EBW) and dressing percentages (DP), being higher for the steers fed *ad libitum* concentrate than other diets. Carcass weight was heaviest in steers fed on diet with high energy-rich concentrate fed *ad libitum* as these steers also had the highest slaughter weight. This result concurs with the earlier studies on fattening of steers using energy-rich concentrates for high meat production (Topps and Oliver, 1993; Luziga, 2005; Frylinck *et al.*, 2005, Weisbjerg *et al.*, 2007; Strydom *et al.* 2008). The higher starting weight of the Boran steers was mirrored by the higher slaughter and carcass weights and dressing percentages compared with the TSHZ ($P<0.05$) which resembles the indigenous local breeds (Nguni) described by Strydom *et al*., (2008).

Steers on Hyc100 dressed out significantly better than Grazc50 and Grazc00. Boran carcasses were heavier and fatter than the TSHZ which probably contributed to its higher DP. The reason for the increased DP could be attributed to increased liveweight and or as fat layer increased more in this diet. These results are in agreement with Meissner *et al*. (1995), that dressing percentage increased as dietary energy concentration increased and Frylinck *et al*. (2005) who reported higher FBW between 324 – 467 kg and DP between 55 – 58% on their study on benchmarking and development of indigenous (Sanga) cattle genotypes finished under feedlot.

The finding that the highest dressing percentage (on empty body mass base) of the steers fed on *ad libitum* concentrates coinciding with heaviest carcass fat weight and lower empty body mass is in agreement with the fact indicated earlier by Preston and Wills (1974) that dressing percentage increases with fatness. In addition, the observed dressing percentage from *ad libitum* concentrate fed were higher than those of Ankole and Senegal Fulani cattle (Joshi *et al.* 1957), TSHZ (Mpiri, 1994) and Iringa red zebu (IRZ) (Nalaila, 2005) but were slightly lower than Boran cattle (Joshi *et al*. 1957). Although differences in genetic make-up of cattle has great influence on dressing percent, Kyomo (1978) found that the level of feeding, weighing procedure, type of diet, degree of fatness and dressing condition could affect the estimate of dressing percent.

The significant variation in gut fill and empty body mass could be explained by variation of the contents in the diets that in turn also influenced the DP. The observed percentage gut fill decreased with increase of concentrate offer in the diets. This was in agreement with other workers that gut full per unit empty body weight declined as animals increase in weight (Schulz *et al.,* 1974; Robelin *et al.,* 1980). This result also concurs with the results in lamb fattening (Suliman and Babiker, 2007) and Norwegian lamb fattening (Mushi, 2009). A large gut and its content result in low dressing percentage.

The significant variation in carcass measurements (carcass length, carcass chest length and carcass limb circumference) between breed was expected because of difference in breed frame size and animal age. This was evidenced by smaller carcass measurements observed in this study than those reported by Mpiri, (1994) for TSHZ and their crosses and Iringa red zebu reported by Nalaila (2005). Body measurements were significantly greater for Boran than for TSHZ in absolute terms, but the opposite was so when they were expressed relative to liveweight. This result is in agreement with the findings reported by McGee *et al.,* (2007) that body measurements were significantly greater for the animals on an intensive system (bulls) than the extensive system. Increasing slaughter weight significantly increased carcass measurements in absolute terms but reduced them relative to weight. The factors affecting killing out percentage in this probably could mainly be due to the effect of breed or strain and body weight which agrees well with observation by Wood *et al.* (1993). High killing out percent in some breeds has attributed to low weights of non-carcass components.

High concentrate offer gave the highest scores in carcass conformation and fatness level, but grazing only gave higher scores in meat colour. This result partly is in agreement with findings by Sañudo *et al.* (2009) that slopes of carcass conformation were related to intramuscular fat and total collagen of which they further showed that higher muscle development would represent leaner and lighter meat and lower total collagen composition. Furthermore, as fatness score increased, positive slopes appeared with intramuscular fatness, showing an important relation to visual and intramuscular fatness. The dark to yellow meat colour observed on Grazc00 were in agreement with other workers (Bidner *et al*. 1986; Schaake *et al*. 1993 and Bennet *et al*. 1995) who found that forage –fed steers had darker meat than grain-fed steers.

The observed weight differences (P<0.0001) between the breeds in rib, lean, fat and bone and the relative proportions could be explained by the variability in genetic composition of the two breeds. Of which it was expected for Boran breed to have a higher weight when compared to their TSHZ counterpart. The results are in agreement with the other studies by Rule *et al*. (1997) and Moreira *et al*. (2003) who worked on *Bos Indicus* and their crosses (*Bos indicus * Bos Taurus*) and showed that carcasses from Boran steers had higher weights of rib, lean, fat and bone as well as their proportions and ratios were higher due to the genetic differences among the two breeds. In this case the slight differences observed could be due to the maturity of the animals that TSHZ were slightly more mature than Boran and hence to have less effect on bone development in both two breeds. The high proportion of lean which increased with increase in concentrate in the diet could be reflected in carcass yield (Slabbert *et al*. 1992; Andersen, 1977; Hicks *et al.* 1988). The fatter steer may have an improved efficiency if its intake is reduced, as noted in some studies (Meissner and Row, 1984; Lofgreen *et al*. 1987). The increase in the amount of fat with increase in supplementation was in agreement with other studies that associated a high plane of nutrition with increased proportion of fat in the carcass (Henrickson *et al.*, 1965; Meyer *et al.* 1965). As expected bone was less affected by concentrate offer during the fattening period, similar observation have been reported by Kerth *et al.* (2007). Bone tissue matures early in life time such that its turnover rate is slower than that of fat and lean later in life (Atti *et al*. 2004). In this study carcass and non carcass components were mainly influenced by finishing diets in both Boran and TSHZ.

Meat quality attributes

Breed difference (P<0.05) in temperature decline was observed on LD at 45 minutes post-mortem (pm) and 6 h pm. In both cases, Boran showed higher values. Apparently, temperature readings at 45 minutes pm showed high values (above normal 37^{o}C) despite the cooling; this was expected due to heat production by the animal from anaerobic processes (Forrest *et al*. 1975).The observed results contradicts to a study by Sinclair *et al*. (2001) who observed no breed difference on temperature decline within 1 h post-mortem (pm), from three beef breeds Aberdeen Angus (34.8 ^{o}C); Charolais (35.6 ^{o}C); Holstein (33.5 ^{o}C). The authors however, observed differences after 10 h pm (Aberdeen Angus (16.3 ^{o}C); Charolais (18.0 ^{o}C); Holstein (14.8 ^{o}C). Nevertheless, the differences observed could be due to differences in carcass bulkiness which is in agreement with Bouton *et al*. (1957).

The significant difference ($P<0.05$) in temperature decline among the diets at 45 minutes, 6 h and 24 h pm, could mainly be due to amount of fat on subcutaneous layer. This result is similar to Andersen *et al*. (2005) who reported breed differences resulting from variation in fat deposition. Variability in fat tissue could also be attributed to the differences in the physiological ages of breeds at the same chronological age and the differences in growth rates between animals (Kempster *et al*., 1982; Micol *et al*., 1993). The observed association between temperature fall to the slaughter weight and carcass fatness is in agreement with Lochner *et al*. (1980) and Bowling *et al*. (1978) who found that heavier carcasses and with more fat layer took longer to cool.

Although pH has been considered to have little economic importance, it is often used to predict other measures of meat quality (Van Laack *et al*. 2001; Melody *et al*., 2004). The rate of pH fall depends on the muscle temperature. In this study no breed difference was observed though, Boran showed higher values than TSHZ. As expected, immediately after slaughter the pH was still above 6.00 at 45 minutes pm and declined to 5.58 - 5.59 at 24 h pm. This is in agreement with the observation made on the indigenous (Sanga) cattle genotypes by Frylinck *et al*, (2006) and on European cattle (Holstein, Old Brown Swiss, Limousin and Blonde d'Aquitaine) by Monsóon, *et al.* (2004) where there was no breed difference up to 24 h pm. The possible reason for this result is that cooling was intermediate as reported also in MLA (2002) and the handling of animal's prior slaughter was un stressful. In this study intermediate temperature cooling on LD was observed where the pH reading reached pH 6 while the temperatures were still high hence there was no cold shortening as has been reported by other workers (MLA, 2002; Purslow, 2002).

The observed breed difference at ultimate pH at 48 h pm in this study could be due to differences in oxidative capacity as well as glycolytic differences where TSHZ might have had high oxidative capacity and high amount of glycogen than Boran where the pH level declined a bit faster post-mortem. Conversely, Boran animals were a bit younger than TSHZ, which implies that they are better at overcoming environmental stress than older animals, as observed by Purslow (2002). Nevertheless, in both breeds, the ultimate pH reached was within the acceptable range, thus could have not affected the WBSF values in subsequent analysis as observed by other workers (Turner *et al* 2008).

Drip loss values were within the normal range (1-5%) as reported by Purslow (2002). In addition it was in agreement with Jama *et al* (2007) who found no breed difference between Nguni, Bonsmara and Angus cattle at the same ageing days but slightly deviates from Frylinck *et al*, (2006) who found breed differences among Sanga cattle. Brugiapaglia *et al*. (2008) also found that Friesians had higher drip losses in comparison with Friesian crossbreds (3.62 vs. 3.08 %; $P<0.05$). Although in this study diets did not show differences in drip loss, *ad libitum* concentrates (Hyc100) had lowest drip loss (3.1%) which was in line with Brugiapaglia *et al*. (2008) who found that higher amount of maize grain in the diet reduced drip losses (3%).

The values obtained on thawing loss were within the range (4-6%) observed by Jeremiah and Gibson (2003). However, the percentage on thawing loss were slightly higher than those reported by Jama *et al* (2007) who found also no breed difference on thawing loss when comparing Nguni (3.26 %), Bonsmara (3.35 %) and Angus (3.60 %).

The observed lack of differences ($P>0.05$) between breeds on cooking loss in this study are in agreement with other workers (Mitsumoto *et al.* 1995; Brugiapaglia *et al*. 2008). However, this result partly contradicts to the observation made by Jama *et al* (2007) who found breed differences ($P<0.05$) in cooking loss when comparing Nguni, Bonsmara and Angus beef cattle but concluded that the differences were mainly due to ageing. Cooking loss was significantly ($P<0.05$) influenced by diets where *ad libitum* concentrates had low cooking loss. This result is in agreement with Brugiapaglia *et al*. (2008) and Xiccato *et al.* (2002).

Although there was no difference ($P>0.05$) in cooking loss between ageing days, it was observed that the percentage losses increased up to day 10 and later decreased at day 21. The result is in agreement with Jama *et al.* (2007) who found a decrease in cooking loss as ageing increased. The result was expected as this could be explained by enzymatic reaction by endogenous enzymes, such as collagenase which are produced by bacteria within beef or ionic solubilization progresses at faster rates as ageing increases. On average cooking loss levels in this study (20.5%) were slightly lower than those reported by Jeremiah and Gibson (2003) which averaged 22.5% and that of Jama *et al.* (2007) who reported 24% and 25.8%, respectively, in two different experiments. The values are also extremely lower than those reported by Razminowicz *et al* (2006) in pasture-fed (or grazing) steers which averaged 30 %. The differences in cooking losses in the current study and those reported by other authors may be attributed to several factors such as the differences in ageing, cooking methods, pH and marbling (Yu *et al.* 2005). Generally, acceptable values on cooking losses were obtained

in this study and the losses were mainly affected by diet and ageing but not by breed. Cooking loss has a large financial implication in beef industry because it results in the loss of several essential minerals and vitamins which results in the deterioration of beef nutritive quality.

The observed difference in shear force between diets was expected. Reasons for the variations could have been differences in slaughter weight among the animals, energy richness in the diets and post-mortem proteolysis. A study by Sañudo *et al*. (2004) revealed that higher slaughter weight results in low WBSF values after heating, which implies that more tender meat for the consumer. The observed high WBSF values from grazing diets (Grazc00 and Grazc50) are in agreement with other studies (Hopkins *et al*., 1993; Mwilawa *et al*. 2009; Andersen *et al*. 2005) who observed that diets with low energy values such as forage or grass had higher WBSF values in comparison to high energy diets from concentrate diets when fed *ad libitum*.

Intramuscular fat and post-mortem proteolysis in *ad libitum* diet (Hyc100) could have great influence on lowering shear force values as also observed by Kristensen *et al*. (2004). Marbling has been associated with eating quality, particularly juiciness and flavour and could make beef more tender as fat is less resistant to WBSF and fat lubricates the mouth while chewing (ZoBell *et al*. 2005). Other workers (Whipple *et al*. 1990; Shackelford *et al*. 1994; Wulf *et al*. 1996) have reported that genetic differences in beef WBSF values are associated with variation in the rate and extent of muscle proteolysis that occurs during post-mortem storage of fresh beef. In this study poor protein turnover was observed in grazing animals and hence could have resulted to a loss in proteolyitic potential (due to inactivation of the proteolytic enzymes), which subsequently leads to reduced tenderization during ageing.

The observed no difference between concentrate fed diets when aged at 10 and 20 days was in agreement with Brito *et al*. (2008) who observed no diet effect ($P>0.05$) in WBSF values in 7 and 14 d of ageing. Also was in agreement with Xiccato *et al.* (2002) and Brugiapaglia *et al*. (2008) who reported that concentrate offered diets had no difference in WBSF in the same ageing time. According to Shackelford *et al.* (1997) who correlated the Warner-Bratzer instrument measures with taste panel or consumer panel scores it was evidenced that different diets attained tender meat in different storage days. In conclusion this study confirms that it is possible to get tender beef from indigenous cattle when fed *ad libitum* concentrate diets in 2 d storage time whereas supplemented diets will require longer time up to 10 d post mortem.

CONCLUSIONS

Breed and diets have significant effect on carcass characteristics evaluated in relation to slaughter weight, hot carcass weight, dressing percentages and carcass classification. Considering commercial products, the increase of final body weight/ slaughter weight or conformation and fatness scores implies important meat quality changes in terms of consumer preferences. Nevertheless, there were differences between breeds in body and carcass measurements, and hence in carcass shape and compactness, but differences in tissue distribution might have been small and therefore, both breeds can be considered potential for increased meat yield.

Carcasses from both breeds attained acceptable ultimate pH range, drip loss and cooking loss which is of interest as it plays a vital role in the overall meat quality. The low shear force values in carcasses from *ad libitum* concentrate indicates tender meat compared to high shear force values from grazing animals indicating less tender meat. It is concluded that both Boran and TSHZ cattle obtained acceptable range of meat quality values and this study confirmed that tender meat can be produced from indigenous cattle through feedlot finishing and post-mortem storage at refrigerated temperatures.

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