

# Carcass and Meat Characteristics of Bulls from Arsi, Boran, Harar and Holstein Frisian Crosses Cattle Breeds Finished under Similar Level of Concentrate Supplementation

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## Abstract

A study was conducted to evaluate the effect of age and breeds (Arsi, Borana, HF-Cross and Harar) on carcass and meat characteristics of bulls finished under similar feeding conditions. The feeding experiment was conducted for 90 days at Beef farm of Haramaya University. In this experiment, 24 bulls were fed with roughage (60%) which contained grass hay and wheat straw and concentrate (40%) which contained wheat bran, noug (*gucia abyssica*) cake, maize grain, limestone, salt and ruminant premix. The bulls were transported to Bishoftu ELFORA export abattoir for slaughter following the procedure of the abattoir. The result of the study revealed that the average slaughter weight, hot carcass weight, cold carcass weight, shrink loss, commercial dressing and true dressing percentage were 179.1 kg, 86.8 kg, 82.7 kg 4.7%, 48.8% and 78.3%, respectively. Total edible and nonedible offal were significantly ( $P < 0.01$ ) influenced by breed and age. Pelvic fat was significantly ( $P < 0.01$ ) influenced by breeds. Meat yield percentages of Arsi, Boran, Harar, and HF-crossbred were 78.1%, 77%, 72.8% and 77.2% respectively. Meat yield was predicted from fat thickness and ribeye area with 61% accuracy. Arsi bulls attained the highest (78%) meat yield at early age but decreased by 0.713 rate as age of animals advanced by one digit whereas the meat yield from other breeds showed increment in meat yield percentage with the rate of 1.98, 1.1 and 0.1 for cross, Borana and Harar breed bulls, respectively as age advanced. Yield from fore shank, sirloin, top and bottom sirloin primal cuts

were affected by breed. Arsi breed had higher meat bone ration than cross breed. Retailed meat yield was significantly ( $P < 0.001$ ) predicted from rib area and subcutaneous fat thickness ( $P < 0.001$ ) with a coefficient of determination 61%, from live animal trait and primal cuts with a coefficient of determination 89.56% and 94.78% respectively. Arsi bulls can be used for beef purpose at 2 - 3 years, as the meat percentage decreases thereafter; while bulls from Boran, cross breed and Harar breeds can be used up to 5 years of age. Meat to bone ratio indicated that HF-Crossbred was less appropriate for beef purpose than other breed bulls in this study. The rate of pH decline was not influence ( $P > 0.05$ ) by age and breed in the current study.

## Keywords

Carcass pH, Meat Characteristics, Carcass Yield

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## 1. Introduction

Ethiopia is one of the lowest per capita meat consuming countries (9 kg/capita/year) compared to consumptions of red meat in Africa [1]. The contribution of beef to the per capita consumption accounted for 4.3 kg/capita/year [2]. The average carcass yield/cattle in Ethiopia was estimated to be 135.90 kg [3] which was below the average carcass yield in developing countries [2]. Clear evidence of the very low productive performance of the livestock sector is due to low genetic potential of indigenous animals and poor livestock husbandry systems [4] [5]. Ethiopia needs to improve the meat sector to achieve its goal of becoming a middle-income country by 2025. It is projected that the population of Ethiopia will grow by 25% between 2012 and 2025, reaching 120 million people by 2030 [6]. The increase in population and the available export market in the Middle East indicate a significant increase in demand for meat and meat products production in Ethiopia [7] [8]. Beef is one of the most widely consumed animal protein sources in human nutrition in Ethiopia and worldwide. To satisfy the meat demand at local and export markets, the country needs to characterize and document the potential of cattle breeds in respect to meat and carcass yield and quality. However, little information is available so far on yields, meat cut and quality characteristics of indigenous cattle breeds in Ethiopia [9] [10].

Some studies were conducted in different corners of the country at different experimental stations like: on Harar bulls [11], Borana, Arsi, and Harar bulls [12], Boran, Kereyu and Ogaden [13] [14] cattle carcass characteristics. However, little information is available on carcass characteristics, meat yield, yield percentage and meat cut of Ethiopian cattle finished under similar preslaughter management. A study by [12] suggested the possibilities of age and breeds of cattle in significantly influencing carcass and meat characteristics bulls from Arsi, Boran, Harar cattle breeds. However, the result was not conclusive as the meat and carcass characteristics of these breeds were evaluated being purchased

directly from their respective production systems. The researchers have suggested the need to determine whether variations are due to genetic or environmental. Hence, evaluation of the three breeds under similar feeding was recommended. Therefore, this study was conducted to evaluate the effect of age and breeds on carcass and meat characteristics of bulls from Arsi, Borana, HF-Cross and Harar breed finished under similar concentrate supplementation.

## 2. Materials and methods

### 2.1. Description of the Study Area

Evaluation of carcass and meat characteristics of cattle breeds were conducted based on slaughter of the bulls at Elfora Beshoftu Abattoir. The abattoir is located 62 km east of Addis Ababa. The experimental animal feeding was conducted at Haramaya University beef fattening unit. It is located at 9.0°N latitude and 42.0°E longitude at an altitude of 1980 m above sea level and 515 km east of Addis Ababa, Ethiopia. The area receives annual average rainfall of 790 mm and annual mean temperature of 16°C.

### 2.2. Animal Management

The experimental animals consist of total of 24 intact bulls were grouped into two age groups (2 - 3 years and 4 - 5 years) of four breeds (Borana, Arsi, Hararghe and Holstein Frisian cross with local breed) of which 6 intact bulls per breeds and 3 intact bulls per age group were used in this study. They were stayed for 90 days being supplied with roughage (60%) and concentrate (40%). The roughage consisted of natural grass hay (55% of roughage) and wheat straw (45% of roughage) and the concentrate consisted of 34.78% wheat bran, 27.8% Noug (*gucia abyssica*) cake, 33.14% maize grain, 1.7% limestone and 1.7% salt and 0.88% ruminant premix.

### 2.3. Experimental Design

A factorial arrangement with two factors (breed and age) and three replications in the CRD (Completely Randomized Design) was used to evaluate carcass yield, quality and meat characteristics as shown in the arrangement was indicated in **Table 1**.

### 2.4. Slaughter Procedure and Evaluation of Carcass and Meat Characteristics

At the end of 90 days experimental feeding, all bulls were loaded on appropriate

**Table 1.** Treatment arrangement to evaluate carcass yield, quality and meat characteristics.

Age	Breeds				Total
	Borane	Arsi	Harar	HF-cross	
2 - 3 yrs	3	3	3	3	12
4 - 5 yrs	3	3	3	3	12
<b>Total</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>24</b>

truck and transported to ELFORA Bishoftu export abattoir. The distance, average speed, total time spent, temperature and relative humidity during travel were recorded as presented in **Table 2**. Hygrometer and thermometer were used to measure humidity and temperature respectively.

The bulls were stayed in the lairage for 60 hrs with free access to water and natural grass hay and fasted for the last 12 hrs. Then the bulls were slaughtered and dressed following the standard procedure of the abattoir.

#### 2.4.1. Evaluation of Carcass Yield: Carcass Weights and Dressing Percentage

Commercial and true dressing percentage was evaluated based on the following parameters. Hot carcass weights (HCW) were recorded immediately after slaughter. Edible offal (heart, liver, kidney, digestive organs,) and nonedible offal (skin, head, feet, blood, spleen, lungs, trachea, genitalia, fat deposit) carcass components were weighed and recorded. The main fat component considered in the study includes (scrotal fat, kidney fat, pelvic fat and omental fat) recorded using sensitive balance. The digestive tract was weighed when full and empty in order to compute the weight of intestinal content.

$$\text{Empty body weight (EBW)} = \text{Slaughterbody weight (kg)} - \text{GIT content (kg)}$$

Dressing percentage was computed as follow:

$$\text{Commercial Dressing Percentage (\%)} = \frac{\text{Hot Carcass Weight (kg)}}{\text{Slaughter Body Weight (kg)}} \times 100$$

$$\text{True Dressing Percentage (\%)} = \frac{\text{Hot Carcass Weight (kg)}}{\text{Edible Body Weight (kg)}} \times 100$$

Total edible proportion (TEP) was computed as:

$$\text{TEP (kg)} = \text{SBW (kg)} - (\text{GIT Content} + \text{hide} + \text{head} + \text{feet} + \text{lung} + \text{trachea}) (\text{kg})$$

#### 2.4.2. Evaluation of Carcass Quality: pH, Ribeye Area and Subcutaneous Fat Thickness

Carcass pH was measured at 45 min post-slaughter (pH45). The carcass was kept in cold room at  $-4^{\circ}\text{C}$  for 24 hrs. The pH of carcass at 6 hrs (pH6), 12 hrs (pH12) and 24 hrs post-slaughter (pH24) were measured using automatic digital

**Table 2.** Climatic variables, distance and speed and total time of the journey.

Variables	Average	Minimum	Maximum
Ambient Temperature ( $^{\circ}\text{C}$ )	25.05	21.5	27.3
Relative humidity (%)	51.85	38	76
Speed of the truck (km/hr)	43.57	30	70
Distance from HU to Bishoftu ELFORA export abattoir (Km)	462		
Total time of the journey (hr)	14		

Km = kilo meter, hr = hour, HU = Haramaya University.

pH meter equipped with a penetrating electrode in order to estimate the rate of PH change and ultimate PH. The pH was directly measure on the longissimus dorsi muscle (LDM) and semitendinosus muscle by incising the muscle for about 5 cm depth by using Portable HANNA pH or temperature meter (model number-HI99163).

At 24 hrs postmortem the following measurement were taken; Longissimus dorsi muscle area (Eye-muscle area) and subcutaneous fat thickness (SFT) were determined between the 12th and 13th ribs using a plastic grid for quick measurement of loin eye (Beef) (Model number-AS-234e) graded in inch square for ribeye area and plastic ruler graded in millimeter was used in SFT measurement. These measurements were performed on the right and left sides of the carcass and the values represent their averages.

### 2.4.3. Evaluation of Meat Yield and Meat Cuts

Beef carcasses were split along the axis of symmetry into halves, then across into forequarters and hindquarters again by using meat saw. Forequarter and hindquarter were separated at between 12th and 13th rib. Carcasses were partitioned into nine major primal cuts based on USA meat cut system. Briefly, Beef On the forequarter the chuck, brisket, rib, plate and fore shank. The beef hind quarter: the flank, the long loin, the round and the short loin. All cuts were deboned carefully; bone and meat were weighed and recorded separately using sensitive balance. The meat was not separated from subcutaneous fat. The weight of total internal fats (fats from the kidney, scrotal, pelvic, and heart) were recorded using sensitive balance.

## 2.5. Statistical Analysis

The data were analyzed using General Linear Model (GLM) procedure of Statistical Analysis System [15]. The multiple regression was used for determination of the most suitable model in prediction of the meat yield using live weight, body condition scoring, ribeye area, fat thickness and major primal cuts as explanatory variables to establish regression equations. The model included the main effects of age and breed in determining carcass yield, quality and meat characteristics. The difference among treatment means were tested using Tukeys' test at 0.05 level of significance.

The models used for the analysis were:

To evaluate carcass, non-carcass, meat characteristics and quality the following model was used.

#### Model I,

$$Y_{ijk} = \mu + A_i + B_j + (A * B)_{ij} + e_{ijk}$$

where,

$Y_{ijk}$  = Response variable,

$\mu$  = Overall mean,

$A_i$  = age effect ( $i = 2$  level),

$B_j$  = breed effect ( $j = 4$  level),  
 $A * B$  = interaction effect of age and breed,  
 $e_{ijk}$  = random error.

#### **Model II,**

To calculate the relationships between meat yield and different explanatory variables.

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

where,

$Y_i$  = dependent variable (meat yield),

$\alpha$  = intercept,

$X_1, X_2, X_3, X_4,$  and  $X_5$  = independent variable (chuck, rib, plate, tenderloin and round) respectively.

$\beta_1, \beta_2, \beta_3, \beta_4$  and  $\beta_5$  = Partial regression slopes corresponding to the respective independent variable (chuck, rib, plate, tender loin and round) respectively.

$\varepsilon$  = Residual.

#### **Model III,**

To calculate the relationships between change in meat yield and live animal condition.

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

where,

$Y_i$  = dependent variable (meat yield),

$\alpha$  = intercept,

$X_1$  and  $X_2$  = independent variable BCS and live weight,

$\beta_1$  and  $\beta_2$  = regression slopes of BCS and live weight,

$\varepsilon$  = Residual.

## **3. Results and Discussion**

### **3.1. Carcass and Non-Carcass Characteristics**

Effect of breeds and age on live, carcass weight and non-carcass characteristics is presented in **Table 3**. In the present study, no breed effect was observed on slaughter weight, hot and cold carcass weight. However, [12] and [16] reported that Borana breed had the highest slaughter and carcass weight compared to Harar and Arsi breeds. However, they have indicated the possibility of confinement of the effect of breed with production systems as the bulls was slaughtered being purchased directly from different production systems. In this study, bulls in the 4 - 5 years age category had higher ( $P < 0.05$ ) slaughter weight, hot and cold carcass weight than their counter part. This variation could be due to the development of muscle and fat in animals increase with increasing age. This finding was in consistence with some of previous works of [12] [16] [17] [18] [19].

Dressing Percentage becomes economically important parameter in carcass evaluation, since hot carcass weight is also affected by values of non-carcass

**Table 3.** Effect of breeds and age on live, carcass weight and non-carcass characteristics.

Category	SBW (kg)	HCW (kg)	CCW (kg)	Sh. Loss (%)	TEOffal (kg)	TNEP (kg)	CDP (%)	TDP (%)
	Mean $\pm$ SE							
<b>Breeds</b>								
Arsi	160.2 $\pm$ 7.9 <sup>a</sup>	82 $\pm$ 4.8 <sup>a</sup>	76.6 $\pm$ 4.5 <sup>a</sup>	6.4 $\pm$ 1.5 <sup>a</sup>	13.2 $\pm$ 0.5 <sup>ab</sup>	32.6 $\pm$ 1.1 <sup>b</sup>	51.1 $\pm$ 0.8 <sup>a</sup>	79.3 $\pm$ 1.9 <sup>a</sup>
Borana	197.3 $\pm$ 15.8 <sup>a</sup>	97.5 $\pm$ 9.7 <sup>a</sup>	91.6 $\pm$ 8.7 <sup>a</sup>	5.8 $\pm$ 0.9 <sup>a</sup>	15.9 $\pm$ 1.0 <sup>a</sup>	39.6 $\pm$ 1.8 <sup>a</sup>	49.1 $\pm$ 1.2 <sup>a</sup>	79.8 $\pm$ 1.3 <sup>a</sup>
HF-Cross	186.2 $\pm$ 18.4 <sup>a</sup>	86.5 $\pm$ 7.9 <sup>a</sup>	85.0 $\pm$ 8.0 <sup>a</sup>	1.8 $\pm$ 0.5 <sup>a</sup>	16.2 $\pm$ 1.5 <sup>a</sup>	36.5 $\pm$ 1.5 <sup>ab</sup>	46.6 $\pm$ 1.2 <sup>a</sup>	76.8 $\pm$ 1.6 <sup>a</sup>
Harar	169.6 $\pm$ 9.3 <sup>a</sup>	81.3 $\pm$ 3.9 <sup>a</sup>	77.6 $\pm$ 4.7 <sup>a</sup>	4.7 $\pm$ 1.4 <sup>a</sup>	12.5 $\pm$ 0.6 <sup>b</sup>	35.0 $\pm$ 1.2 <sup>ab</sup>	48.3 $\pm$ 1.0 <sup>a</sup>	77.3 $\pm$ 1.8 <sup>a</sup>
P-value	NS	NS	NS	NS	**	**	NS	NS
<b>Age</b>								
2 - 3 yrs	158.1 $\pm$ 5.9 <sup>b</sup>	78 $\pm$ 3.2 <sup>b</sup>	73.5 $\pm$ 3.2 <sup>b</sup>	5.8 $\pm$ 1.0 <sup>a</sup>	13.1 $\pm$ 0.4 <sup>b</sup>	33.9 $\pm$ 1.0 <sup>b</sup>	49.3 $\pm$ 0.7 <sup>a</sup>	79.4 $\pm$ 0.8 <sup>a</sup>
4 - 5 yrs	198.1 $\pm$ 9.9 <sup>a</sup>	95.6 $\pm$ 5.3 <sup>a</sup>	92.0 $\pm$ 4.7 <sup>a</sup>	3.6 $\pm$ 0.7 <sup>a</sup>	15.9 $\pm$ 0.9 <sup>a</sup>	38.1 $\pm$ 1.1 <sup>a</sup>	48.3 $\pm$ 0.9 <sup>a</sup>	77.2 $\pm$ 1.4 <sup>a</sup>
P-value	**	*	**	NS	**	**	NS	NS
Overall	179.1 $\pm$ 1.0	86.8 $\pm$ 3.5	82.7 $\pm$ 3.4	4.7 $\pm$ 0.6	14.5 $\pm$ 0.5	35.9 $\pm$ 0.8	48.8 $\pm$ 0.6	78.3 $\pm$ 0.8
<b>Breed * Age</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>CV</b>	<b>14.8</b>	<b>17.6</b>	<b>17.3</b>	<b>26.5</b>	<b>13.3</b>	<b>8.6</b>	<b>5.7</b>	<b>5.0</b>

Mean values under the same category that bear different superscript letters are significantly different, NS =  $P > 0.05$ , \*\*\* =  $P < 0.001$ , \*\* =  $P < 0.01$ ; \* =  $P < 0.05$ , SE = standard error of mean, HF-cross = Holstein Frisian crossbred, CV = Coefficient of variation, kg = kilo gram, SBW = slaughter body weight, HCW = hot carcass weight, CCW = cold carcass weight, SH. Loss = shrink loss, TE = total edible, TNEP = total non-edible portion, CDP = commercial dressing percentage, TDP = true dressing percentage.

weight which includes values of economically less important components of the carcass such as head, feet, skin as well as visceral [20]. Especially edible offal is the most economically important components of carcass in Ethiopia as well as almost all over the world. So therefore, it is better if total edible portion of the carcass is considered in calculation of dressing percentage to get actual or true dressing percentage. Commercial (CDP) and True (TDP) dressing percentage were not affected by breeds and age groups in the present result. However, the dressing percentage of Borana breed in the current study was lower than that reported for the same breed reported by [10], who noted 54.78%, [21] noted 52% for Ethiopian Borana and 55.7% for Improved Borana; whereas higher than the value 45.15%, 43.9%, 47% and 47.49% reported by [12] [16] [17] [22] respectively. Dressing percentage of Arsi breed was comparable with the report by [23] which was 51.5%, [24] which was 50.3% for the same breed. For HF-Crossbred the value was lower than the report by [25] 51.6% for Guzerat-HF crossbred bulls in Brazil. For Harar breed the value obtained in this study was higher than the report by [16]. [10] reported lower dressing percentage for Arado, Barka and Raya cattle breeds slaughtered in Northern part Ethiopia.

Moreover, the overall dressing percentage value in the current study was higher than previous works on similar breeds by [12] and [16] noted 46.38% and 45.46% respectively.

Regardless of the significant ( $P < 0.05$ ) difference in slaughter and hot carcass

weight, age didn't influence ( $P > 0.05$ ) dressing percentage. This may be due to similar proportions of carcass to live weight ratio across different age groups since dressing percentage is related to slaughter body weight. This is in line with those previous report by [12] and [26]. Dressing percentage variation may occur as a result of differences on the genotypes, localities and/or conditions of animals [27], sex and age of the animals [11].

Weight loss during carcass chilling is a significant economic consideration for the red meat industry [28]. Chilling loss within 24 hrs was not affected by age and breed in the current study. Similarly [25] reported no difference among breed on cold shrink loss. According to [18] chilling loss was affected by the level of subcutaneous fat thickness. The subcutaneous fat thickness, which works as an insulator, avoiding losses by dehydration does not influenced by breeds and age in this study as presented in (Table 5). Therefore, carcasses with comparable fat content have almost similar losses during chilling process [25]. The overall chilling loss percentage in this study was higher than those report by [29] noted 1.36% for *Boss Taurus* beef chilled for 24 hrs, [25] 3.0% for Guzerat-HF crossbred bulls in Brazil. The weight loss of beef carcasses during the first 24 hrs was reported to range from 1.1% to 2.1% for *Boss Taurus* in the UK [30], 0.4% to 2.2% in Brazil [31].

The superiority ( $P < 0.01$ ) of total edible offal (Heart + kidney + liver + stomach + largeintestine + small intestine) of HF-Crossbred and Borana bulls in relation to Harar bulls were observed in the present study, whereas intermediate value was recorded for Arsi bulls. In addition to carcass cut, total edible offal is also another economically important portion of non-carcass output for wholesalers and retailers. Therefore, the wholesalers and retailers desire a carcass that yields more components to be utilized. The finding was in agreement with [32] [33] finding which reported higher edible portion would provide minor amounts of losses and higher percentages of pieces that allow overall edible portion and highest commercial value. The older age group (4 - 5 years) the higher ( $P < 0.01$ ) total edible offal and total non-edible portion. This might be attributed to the increase in size of animals' body organs and different body parts with increasing age.

Considering total non-edible portion (Head with horn, Feet, Blood, Spleen, Pancreas, Trachea with lung, Penis, Testicle, Bladder, Gallbladder, and Hide), Borana bulls showed a significantly higher ( $P < 0.01$ ) weight than Arsi bulls while Harar and HF-Crossbred were intermediate. This may be due to heavier body conformation in Borana bulls, the higher carcass and non-carcass portion proportionally. This finding was in agreement with [34] and [35] who had reported that animals with larger body had larger body organs.

### 3.2. Meat Yield Percentage

Effect of breed and age on meat yield percentage are presented in Table 4. Meat yield percent was significantly ( $P < 0.0001$ ) influenced by breed. This is in agreement with the report of [10] for Arado, Raya, Barka and Borana cattle. In



**Table 4.** Effect of age and breed on meat yield percentage and ribeye area.

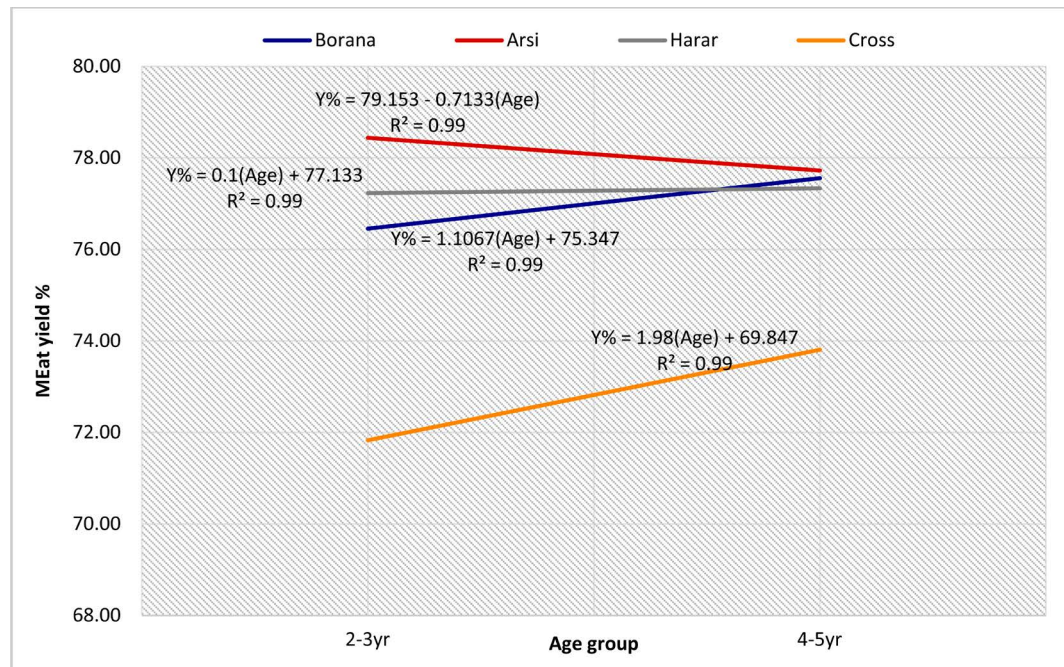
Category	Carcass proportion (%)		Ribeye area (inch <sup>2</sup> )
	Meat + fat	Bone	
	(Mean ± SE)		
<b>Breeds</b>			
Arsi	78.1 ± 0.26 <sup>a</sup>	21.9 ± 0.26 <sup>b</sup>	5.60 ± 3.33
Borana	77.0 ± 0.82 <sup>a</sup>	22.99 ± 0.85 <sup>b</sup>	6.23 ± 5.26
HF-Cross	72.8 ± 0.67 <sup>b</sup>	27.18 ± 0.67 <sup>a</sup>	5.28 ± 5.51
Harar	77.2 ± 0.64 <sup>a</sup>	22.71 ± 0.64 <sup>b</sup>	6.05 ± 4.58
Sig.	***	***	NS
<b>Age</b>			
2 - 3 yrs	75.98 ± 0.82 <sup>a</sup>	24.01 ± 0.82 <sup>a</sup>	5.15 ± 2.27 <sup>b</sup>
4 - 5 yrs	76.60 ± 0.67 <sup>a</sup>	23.39 ± 0.67 <sup>a</sup>	6.42 ± 3.24 <sup>a</sup>
Sig.	Ns	Ns	**
<b>Overall</b>	<b>76.2 ± 0.52</b>	<b>23.7 ± 0.52</b>	<b>5.791 ± 2.34</b>
<b>Breed*Age</b>	<b>*</b>	<b>Ns</b>	<b>Ns</b>

Mean values under the same category that bear different superscript letters are significantly different, Ns =  $P > 0.05$ , \*\*\* =  $P < 0.001$ , \*\* =  $P < 0.01$ ; \* =  $P < 0.05$ , SE = standard error of mean, HF-cross = Holstein Friesian crossbred.

the current result HF-Crossbred bulls has relatively lower (72.8%) meat yield compared to the three breed (Arsi, Borana and Harar) bulls in which the latter were statistically similar. Meat yield percent did not influenced by age. The overall yield percent (76.2%) in the current finding was higher than those previous finding by [12] noted that yield percent were ranged between 35% to 60% for the same breed with the current finding, [10] Mumm and Webb (2019) also reported 67.81% yield percentage for Arado, Raya and Barka breed, [36] reported for Nguni (72.5%) and Tuli (73%) cattle in South Africa. Generally the comparison of the current result with the [12] finding showed the importance of concentrate supplementation to improves meat yield percent from bulls.

Ribeye area is the most useful technique used to indicate the muscle amount obtained from the total carcass of meat animals. Breed has no significant ( $P > 0.05$ ) influence on ribeye area but the older age group (4 - 5 years) attained higher ( $P < 0.01$ ) ribeye areas than 2 - 3 years old bulls. This may be due to as animals increase in age muscularity and cut yield also increased. This is in line with the previous report by [12] [37] [38].

Breed by age interaction effected meat yield percentage as presented in **Figure 1**. The figure shows that there was linear rate of meat yield increment from two to five years old bulls of Borana, Harar and HF-Crossbred. Greater rate of yield percent increment was observed for the HF-Crossbred which was 1.98 followed by Borana and Harar with 1.1 and 0.1 rate of increment respectively as age advanced. But Arsi bulls attain the highest (78%) yield at an early age but decrease



**Figure 1.** Age by breed interaction on meat yield percent of Arsi, Boran, Harar and HF-Crossbred bulls.

by 0.713 rate as age of animals advanced by one digit. This is corroborated by [12] who reported that rate of yield percent decreased by 0.93 for the Arsi breed as the age advanced from one category to the other. This variation in meat yield percent could be due to variation in live weight of different breeds in different age categories. This is in line with the report of [10] for Arado, Barka and Rayya cattle in Ethiopia, [39] for Angus, limousine and Wagyu cattle in Australia. Generally, this figure shows that supplementing Arsi bulls with age of above five years old is not economically profitable in terms of meat yield percentage as compared with Borana, Harar and HF-Crossbred bulls.

### 3.3. Effect of Age and Breed on Fat Characteristics and Ribeye Area

In the current study, scrotal fat, kidney fat, heart fat, omental fat and subcutaneous fat thickness were not affected by age and breeds as shown in **Table 5**. This is in agreement with the finding of [12] who reported that there were no breed effects on kidney, heart fat and subcutaneous fat thickness for the same breed to the current study. Similarly, [25] also reported no breed effect for subcutaneous fat thickness of the Guzerat and their HF-crossbred bulls in Brazil, [22] also reported that no breed effect was observed in heart fat, subcutaneous fat thickness and ribeye area for Borana and Kereyu breed bulls. In contrast to the current finding [22] reported that Borana bulls recorded significantly higher ( $P < 0.05$ ) pelvic fat, scrotal fat and kidney fat values than Kereyu bulls, [17] also reported that age significantly influence scrotal fat, kidney fat, heart fat, omental fat and subcutaneous fat thickness in Borana bulls. The overall weight record of kidney and heart fat in the current study were higher than 0.21 and 0.17 kg

**Table 5.** Effect of age and breed on fat characteristics.

Category	Scrotal fat (kg)	Kidney fat (kg)	Pelvic fat (kg)	Heart fat (kg)	Omental fat (kg)	SFT (mm)
	Mean $\pm$ SE					
<b>Breeds</b>						
Arsi	0.48 $\pm$ 0.04	0.61 $\pm$ 0.05	0.27 $\pm$ 0.03 <sup>ab</sup>	0.52 $\pm$ 0.06	0.82 $\pm$ 0.11	6.25 $\pm$ 1.18
Borana	0.67 $\pm$ 0.12	0.61 $\pm$ 0.13	0.42 $\pm$ 0.06 <sup>a</sup>	0.62 $\pm$ 0.09	1.12 $\pm$ 0.22	4.0 $\pm$ 1.09
HF-Cross	0.44 $\pm$ 0.07	0.56 $\pm$ 0.08	0.21 $\pm$ 0.04 <sup>b</sup>	0.41 $\pm$ 0.05	0.8 $\pm$ 0.13	3.91 $\pm$ 0.84
Harar	0.5 $\pm$ 0.03	0.57 $\pm$ 0.09	0.27 $\pm$ 0.05 <sup>ab</sup>	0.58 $\pm$ 0.07	0.78 $\pm$ 0.06	4.25 $\pm$ 0.77
P-value	NS	NS	*	NS	NS	NS
<b>Age</b>						
2 - 3 yrs	0.46 $\pm$ 0.03	0.55 $\pm$ 0.06	0.31 $\pm$ 0.04	0.52 $\pm$ 0.05	0.83 $\pm$ 0.11	3.62 $\pm$ 0.52
4 - 5 yrs	0.58 $\pm$ 0.06	0.59 $\pm$ 0.06	0.28 $\pm$ 0.03	0.56 $\pm$ 0.05	0.93 $\pm$ 0.09	5.58 $\pm$ 0.78
P-value	NS	NS	NS	NS	NS	NS
<b>Overall</b>	<b>0.52 <math>\pm</math> 0.04</b>	<b>0.57 <math>\pm</math> 0.04</b>	<b>0.29 <math>\pm</math> 0.02</b>	<b>0.53 <math>\pm</math> 0.03</b>	<b>0.88 <math>\pm</math> 0.07</b>	<b>4.6 <math>\pm</math> 0.50</b>
<b>Breed*Age</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>
<b>CV</b>	<b>36.4</b>	<b>43.9</b>	<b>37.4</b>	<b>33.8</b>	<b>40.5</b>	<b>40.7</b>

Mean values under the same category that bear different superscript letters are significantly different, ns =  $P > 0.05$ , \*\*\* =  $P < 0.001$ , \*\* =  $P < 0.01$ ; \* =  $P < 0.05$ , SE = standard error of mean, HF-cross = Holstein Friesian crossbred, CV = Coefficient of variation, kg = kilo gram, SFT = subcutaneous fat thickness, mm = millimeter.

respectively reported by [12] for the same breeds finished in different production systems to the current study. The overall subcutaneous fat thickness value in this study was higher than the value (0.45 mm to 0.96 mm) reported by [12] for the same breeds to the current study, (3.3 mm to 4.3 mm) value reported by [27] for Afar bulls, 3.75 mm reported by [22] for Borana and Kereyu bulls, but lower than 4.82 mm value reported by [25] for Guzerat and their HF-crossbred bulls in Brazil. The different in the report in this respect can be associated with feeding condition before slaughter. The overall scrotal and omental fat recorded in this study were lower than 0.73 kg and 1.2 kg respectively as reported by [17] for Borana bulls of 2 and 4 years old. Similarly [22] reported 1.01 kg scrotal fat for Borana and Kereyu bulls.

Borana breed under similar management conditions deposited significantly higher ( $P < 0.05$ ) pelvic fat than HF-Crossbred bulls whereas Harar and Arsi bulls deposited intermediate value. This is in agreement with the report of [22] that Borana bulls significantly higher ( $P < 0.05$ ) pelvic fat than Kereyu bulls under similar management. In contrast to the current result [12] reported that there was no significant difference ( $P > 0.05$ ) in pelvic fat content among the breeds.

### 3.4. Correlation between Meat Yield and Fat Characteristics

According to the result presented in **Table 6** scrotal fat was strongly ( $P < 0.0001$ )

**Table 6.** Correlation between meat yield and fat characteristics of Arsi, Borana, Harar and HF-Crossbred bulls.

	SF	KF	PF	OF	TF	REA	SFT	MY
SF	1	0.07 <sup>ns</sup>	0.18 <sup>ns</sup>	0.26 <sup>ns</sup>	0.49*	0.61**	0.37 <sup>ns</sup>	0.72***
KF		1	0.26 <sup>ns</sup>	0.61**	0.73***	0.22 <sup>ns</sup>	-0.29 <sup>ns</sup>	0.11 <sup>ns</sup>
PF			1	0.43*	0.58**	0.21 <sup>ns</sup>	-0.05 <sup>ns</sup>	0.12 <sup>ns</sup>
OF				1	0.91***	0.36 <sup>ns</sup>	0.15 <sup>ns</sup>	0.36 <sup>ns</sup>
TF					1	0.49*	0.08 <sup>ns</sup>	0.46*
REA						1	0.45*	0.75***
SFT							1	0.51**
MY								1

SF = scrotal fat, KF = kidney fat, PF = pelvic fat, OF = omental fat, TF = total fat, REA = ribeye area, SFT = subcutaneous fat thickness, MY = meat yield, ns =  $P > 0.05$ , \*\*\* =  $P < 0.001$ , \*\* =  $P < 0.01$ ; \* =  $P < 0.05$ .

correlated with meat yield ( $r = 0.72$ ), and also highly ( $P < 0.001$ ) correlated with ribeye area ( $r = 0.61$ ). Kidney fat was strongly ( $P < 0.0001$ ) correlated with total fat ( $r = 0.73$ ), and omental fat ( $r = 0.61$ ), while negatively correlated with subcutaneous fat thickness. Pelvic fat somewhat highly correlated (0.01) with total fat ( $r = 0.58$ ) and omental fat ( $r = 0.43$ ), while negatively correlated with subcutaneous fat thickness. Omental fat has strong ( $P < 0.0001$ ) correlation with total fat. Ribeye area has strong ( $P < 0.0001$ ) correlation with meat yield. Subcutaneous fat thickness had shown strong ( $P < 0.001$ ) correlation with meat yield. Generally, meat yield was strongly correlated with scrotal, subcutaneous fat and ribeye area. The relative proportionality of fat thickness with carcass weight may be due to the slight increment in deposition of fat tissue as cattle advances with body weight. On the other hand, the relative proportions of specific tissues change as the animal matures, typified by reductions in the growth rates of muscle and bone and increasing rates of fat deposit [18] [40] [41].

The result of this research was in agreement to the report of [42] [43] that the fat thickness and ribeye area on the 12th rib resulting highly significant correlation ( $P < 0.0001$ ) with content of meat yield. This research created the best multiple regression equation to predict meat yield based on fat thickness and ribeye area as follows:

$$MY = 8.49 + 0.41(REA) + 0.65(SFT)$$

having  $R^2 = 61\%$ , RMSE = 4.69,  $P < 0.0001$ .

Where, MY = meat yield in Kg, REA = ribeye area in inch square, SFT = subcutaneous fat thickness in millimeter, RMSE = Root mean square error,  $R^2$  = coefficient of determination.

### 3.5. Meat Yield, Percentage, Primal Meat Cuts and Proportion of Bone Component

The average meat yields from forequarter and hindquarter weight were pre-

sented in **Table 7**. Breed did not influence fore and hindquarter weight of meat yield while bulls in 4 - 5 years old has significantly ( $P < 0.01$ ) heavier meat yield than 2 - 3 years old bulls, particularly, in chuck, Rib, Plate, Tenderloin, Top sirloin, fore- and hindquarter. The heavier fore- and hindquarter in older age bulls (4 - 5 years) could be due to heavier live and carcass weight of bulls than 2 - 3 years age category. In line with the current finding, some research findings reported that a heavier live and carcass weights were reflected in heavier primal cuts for Borana, Arsi, Harar breed [10] [12] [17]. The mean value of meat weight from each carcass cut of forequarter was not affected by breed except for Fore shank. The weight of meat cut from HF-Crossbred was relatively heavier ( $P < 0.05$ ) than the cut from Arsi bulls whereas Borana and Harar recorded intermediate value for Fore-shank.

The mean Sirloin from HF-Cross was significantly ( $P < 0.05$ ) heavier than Harar but the reverse is true for Top-sirloin, whereas Arsi and Borana attain intermediate weight for both Sirloin and Top-sirloin. Borana yielded significantly high ( $P < 0.01$ ) weight of Bottom-sirloin than Arsi and Harar. In line to the current result, [12] reported better performance of Bottom-sirloin for Borana breed than Arsi and Harar.

The proportion of carcass component and meat yield from Arsi, Borana, Cross

**Table 7.** Effect of age and breeds of Arsi, Borana, Cross and Harar bulls on weight of boneless meat from each primal cuts.

Primal cuts (kg)	Breeds				Sig.	Age		Sig.	Overall
	Arsi	Borana	HF-Cross	Harar		2 - 3 yr	4 - 5 yr		
	Mean $\pm$ SE					Mean $\pm$ SE			Mean $\pm$ SE
<b>Fore quarter</b>	14.16 $\pm$ 1.47	15.95 $\pm$ 2.0	13.53 $\pm$ 2.2	13.58 $\pm$ 1.09	Ns	11.62 $\pm$ 0.82 <sup>b</sup>	16.87 $\pm$ 1.02 <sup>a</sup>	*	14.25 $\pm$ 0.84
Chuck	8.9 $\pm$ 0.89	10.63 $\pm$ 1.40	8.5 $\pm$ 1.64	8.83 $\pm$ 0.58	Ns	7.6 $\pm$ 0.7 <sup>b</sup>	10.83 $\pm$ 0.69 <sup>a</sup>	**	9.21 $\pm$ 0.58
Brisket	1.96 $\pm$ 0.96	1.00 $\pm$ 0.14	0.966 $\pm$ 0.20	1 $\pm$ 0.19	Ns	0.79 $\pm$ 0.1	1.67 $\pm$ 0.46	Ns	1.23 $\pm$ 0.25
Rib	1.98 $\pm$ 0.19	2.2 $\pm$ 0.28	1.98 $\pm$ 0.29	2.1 $\pm$ 0.37	Ns	1.71 $\pm$ 0.13 <sup>b</sup>	2.4 $\pm$ 0.19 <sup>a</sup>	*	2.0 $\pm$ 0.13
Plate	0.56 $\pm$ 0.06	0.75 $\pm$ 0.13	0.66 $\pm$ 0.07	0.56 $\pm$ 0.12	Ns	0.51 $\pm$ 0.02 <sup>b</sup>	0.75 $\pm$ 0.08 <sup>a</sup>	*	0.63 $\pm$ 0.05
Fore shank	0.8 $\pm$ 0.08 <sup>b</sup>	1.35 $\pm$ 0.15 <sup>ab</sup>	1.41 $\pm$ 0.2 <sup>a</sup>	0.88 $\pm$ 0.14 <sup>ab</sup>	*	1.0 $\pm$ 0.08	1.22 $\pm$ 0.16	Ns	1.11 $\pm$ 0.09
<b>Hind quarter</b>	19.71 $\pm$ 0.79	23.36 $\pm$ 1.67	20.58 $\pm$ 1.74	20.65 $\pm$ 0.83	Ns	19.22 $\pm$ 0.62 <sup>b</sup>	22.93 $\pm$ 0.98 <sup>a</sup>	**	21.07 $\pm$ 0.68
Flank	0.6 $\pm$ 0.13	0.73 $\pm$ 0.13	0.81 $\pm$ 0.14	0.68 $\pm$ 0.11	Ns	0.65 $\pm$ 0.08	0.76 $\pm$ 0.09	Ns	0.71 $\pm$ 0.06
Short Loin	2.0 $\pm$ 0.2	2.9 $\pm$ 0.45	2.06 $\pm$ 0.3	1.86 $\pm$ 0.12	Ns	1.91 $\pm$ 0.13	2.51 $\pm$ 0.28	Ns	2.20 $\pm$ 0.16
Sirloin	1.91 $\pm$ 0.13 <sup>ab</sup>	2.2 $\pm$ 0.29 <sup>ab</sup>	2.88 $\pm$ 0.39 <sup>a</sup>	1.75 $\pm$ 0.13 <sup>b</sup>	*	2.12 $\pm$ 0.24	2.25 $\pm$ 0.19	Ns	2.18 $\pm$ 0.15
Tender Loin	0.76 $\pm$ 0.08	1.2 $\pm$ 0.16	0.93 $\pm$ 0.14	0.86 $\pm$ 0.11	Ns	0.79 $\pm$ 0.06 <sup>b</sup>	1.09 $\pm$ 0.11 <sup>a</sup>	*	0.94 $\pm$ 0.06
Top Sirloin	3.71 $\pm$ 0.35 <sup>ab</sup>	4.01 $\pm$ 0.47 <sup>ab</sup>	2.88 $\pm$ 0.44 <sup>b</sup>	4.41 $\pm$ 0.23 <sup>a</sup>	*	3.33 $\pm$ 0.34 <sup>b</sup>	4.18 $\pm$ 0.20 <sup>a</sup>	*	3.75 $\pm$ 0.21
Bottom Sirloin	1.55 $\pm$ 0.14 <sup>b</sup>	2.46 $\pm$ 0.32 <sup>a</sup>	2.25 $\pm$ 0.17 <sup>a</sup>	1.95 $\pm$ 0.18 <sup>ab</sup>	**	1.78 $\pm$ 0.12 <sup>b</sup>	2.32 $\pm$ 0.18 <sup>a</sup>	**	2.05 $\pm$ 0.12
Round	8.43 $\pm$ 0.27	8.63 $\pm$ 0.43	7.48 $\pm$ 0.56	8.01 $\pm$ 0.46	Ns	7.62 $\pm$ 0.26 <sup>b</sup>	8.65 $\pm$ 0.30 <sup>a</sup>	*	8.14 $\pm$ 0.22
Hind Shank	0.78 $\pm$ 0.10	1.23 $\pm$ 0.15	1.26 $\pm$ 0.22	1.06 $\pm$ 0.11	Ns	1.00 $\pm$ 0.08	1.16 $\pm$ 0.14	Ns	1.08 $\pm$ 0.08

Mean values under the same category that bear different superscript letters are significantly different, Ns =  $P > 0.05$ , \*\*\* =  $P < 0.001$ , \*\* =  $P < 0.01$ ; \* =  $P < 0.05$ , SE = standard error of mean, HF-cross = Holstein Frisian crossbred.

and Harar breeds are presented in **Table 8**. There is no significant difference ( $P > 0.05$ ) concerning meat accumulation on all primal cut except on chuck and rib between the four experimental breeds in the current study. HF-Crossbred bulls accumulated lower ( $P < 0.01$ ) meat in both chuck and rib primal cut than Arsi, Borana and Harar bulls. Similarly, higher ( $P < 0.01$ ) total bone proportion

**Table 8.** Proportion of carcass components and meat yield of Arsi, Borana, HF-Cross and Harar bulls.

Primal cut	Components proportion (%)	Breeds				Sig.	Overall
		Arsi	Borana	HF-Cross	Harar		
		Mean $\pm$ SE					
Chuck	Meat	78.26 $\pm$ 1.55 <sup>a</sup>	76.44 $\pm$ 1.78 <sup>a</sup>	69.01 $\pm$ 1.74 <sup>b</sup>	77.19 $\pm$ 0.65 <sup>a</sup>	**	75.22 $\pm$ 1.03
	Bone	21.73 $\pm$ 1.55 <sup>b</sup>	23.56 $\pm$ 1.78 <sup>b</sup>	30.98 $\pm$ 1.74 <sup>a</sup>	22.80 $\pm$ 0.65 <sup>b</sup>	**	24.77 $\pm$ 1.03
	Meat yield	25.99 $\pm$ 1.76	26.67 $\pm$ 1.03	23.84 $\pm$ 2.84	25.92 $\pm$ 0.95	ns	25.61 $\pm$ 0.87
Brisket	Meat	68.68 $\pm$ 5.10	66.45 $\pm$ 1.95	58.72 $\pm$ 4.05	60.72 $\pm$ 5.85	ns	63.64 $\pm$ 2.25
	Bone	31.31 $\pm$ 5.10	33.55 $\pm$ 1.95	41.28 $\pm$ 4.05	39.27 $\pm$ 5.85	ns	36.35 $\pm$ 2.25
	Meat yield	5.54 $\pm$ 2.41	2.53 $\pm$ 0.29	2.71 $\pm$ 0.29	2.85 $\pm$ 0.49	ns	3.41 $\pm$ 0.63
Rib	Meat	65.7 $\pm$ 1.83 <sup>a</sup>	68.03 $\pm$ 2.36 <sup>a</sup>	56.48 $\pm$ 2.11 <sup>b</sup>	66.94 $\pm$ 1.25 <sup>a</sup>	**	64.29 $\pm$ 1.31
	Bone	34.3 $\pm$ 1.83 <sup>b</sup>	31.96 $\pm$ 2.36 <sup>b</sup>	43.51 $\pm$ 2.11 <sup>a</sup>	33.05 $\pm$ 1.25 <sup>b</sup>	**	35.70 $\pm$ 1.31
	Meat yield	5.68 $\pm$ 0.25	5.52 $\pm$ 0.37	5.72 $\pm$ 0.44	6.05 $\pm$ 0.76	ns	5.74 $\pm$ 0.23
Plate	Meat	53.84 $\pm$ 4.56	51.14 $\pm$ 3.71	50.32 $\pm$ 2.92	44.59 $\pm$ 7.32	ns	49.97 $\pm$ 2.39
	Bone	46.15 $\pm$ 4.56	48.85 $\pm$ 3.71	49.67 $\pm$ 2.92	55.40 $\pm$ 7.32	ns	50.02 $\pm$ 0.22
	Meat yield	1.67 $\pm$ 0.10	1.89 $\pm$ 0.15	1.97 $\pm$ 0.09	1.58 $\pm$ 0.31	ns	1.78 $\pm$ 0.09
Fore shank	Meat	57.32 $\pm$ 6.48	56.22 $\pm$ 3.39	54.38 $\pm$ 1.69	50.55 $\pm$ 3.06	ns	54.62 $\pm$ 1.96
	Bone	42.67 $\pm$ 6.48	43.77 $\pm$ 3.39	45.61 $\pm$ 1.69	49.45 $\pm$ 3.06	ns	45.37 $\pm$ 1.96
	Meat yield	2.36 $\pm$ 0.25 <sup>a</sup>	3.4 $\pm$ 0.17 <sup>ab</sup>	4.25 $\pm$ 0.52 <sup>a</sup>	2.61 $\pm$ 0.40 <sup>b</sup>	*	3.14 $\pm$ 0.22
Flank	Meat	100 $\pm$ 0.00	100 $\pm$ 0.0	100 $\pm$ 0.00	100 $\pm$ 0.00	ns	100 $\pm$ 0.00
	Bone	0	0	0	0	ns	0
	Meat yield	1.81 $\pm$ 0.46	1.87 $\pm$ 0.26	2.34 $\pm$ 0.18	2.01 $\pm$ 0.31	ns	2.01 $\pm$ 0.15
Loin(short, sir, tender, top and bottom Loin)	Meat	91.71 $\pm$ 0.46	91.85 $\pm$ 0.94	90.62 $\pm$ 1.01	92.91 $\pm$ 0.52	ns	91.77 $\pm$ 0.39
	Bone	8.28 $\pm$ 0.46	8.14 $\pm$ 0.94	9.37 $\pm$ 1.01	7.08 $\pm$ 0.52	ns	8.22 $\pm$ 0.39
	Meat yield	29.29 $\pm$ 1.18	32.26 $\pm$ 0.94	32.82 $\pm$ 2.00	32.02 $\pm$ 0.55	ns	31.30 $\pm$ 0.66
Round	Meat	76.97 $\pm$ 0.99	74.45 $\pm$ 1.70	73.99 $\pm$ 3.71	75.35 $\pm$ 1.80	ns	75.19 $\pm$ 1.09
	Bone	23.02 $\pm$ 0.99	25.55 $\pm$ 1.70	26.00 $\pm$ 3.71	24.64 $\pm$ 1.80	ns	24.80 $\pm$ 1.09
	Meat yield	25.19 $\pm$ 1.23	22.70 $\pm$ 1.88	22.71 $\pm$ 1.82	23.73 $\pm$ 1.19	ns	23.58 $\pm$ 0.87
Hind Shank	Meat	47.87 $\pm$ 5.02	52.8 $\pm$ 2.80	49.13 $\pm$ 2.99	53.14 $\pm$ 2.77	ns	50.73 $\pm$ 1.71
	Bone	52.12 $\pm$ 5.02	47.2 $\pm$ 2.80	50.86 $\pm$ 2.99	46.85 $\pm$ 2.77	ns	49.26 $\pm$ 1.71
	Meat yield	2.42 $\pm$ 0.37	3.12 $\pm$ 0.32	3.65 $\pm$ 0.32	3.20 $\pm$ 0.38	ns	3.1 $\pm$ 0.18

Mean values under the same category that bear different superscript letters are significantly different, ns =  $P > 0.05$ , \*\*\* =  $P < 0.001$ , \*\* =  $P < 0.01$ ; \* =  $P < 0.05$ , SE = standard error of mean, HF-cross = Holstein Frisian crossbred.

were observed for HF-Crossbreed in chuck and rib primal. There is no significant difference ( $P > 0.05$ ) concerning meat yield percentage of each primal cut from the carcass except for Fore shank. Higher ( $P < 0.05$ ) meat yield was observed for HF-Crossbreed in case of fore shank percentage from whole carcass.

The prediction equations to estimate meat yield from live body weight, body condition score and some of major primal cuts are presented in **Table 9**. Meat yield can be effectively predicted from live animal traits like live weight and body condition score with coefficient determination ( $R^2$ ) of 89.56%. Chuck, rib, plate, tenderloin and round were with the accuracy of prediction 84.08%, 32.86%, 67.33%, 71.81% and 59.23%, respectively. The value of coefficient of determination ( $R^2$ ) increased as more primal cuts are added to the regression equation (94.78%). The higher  $R^2$  value and smaller MSE attained showed good meat yield prediction equation.

### 3.6. Rate of pH Decline

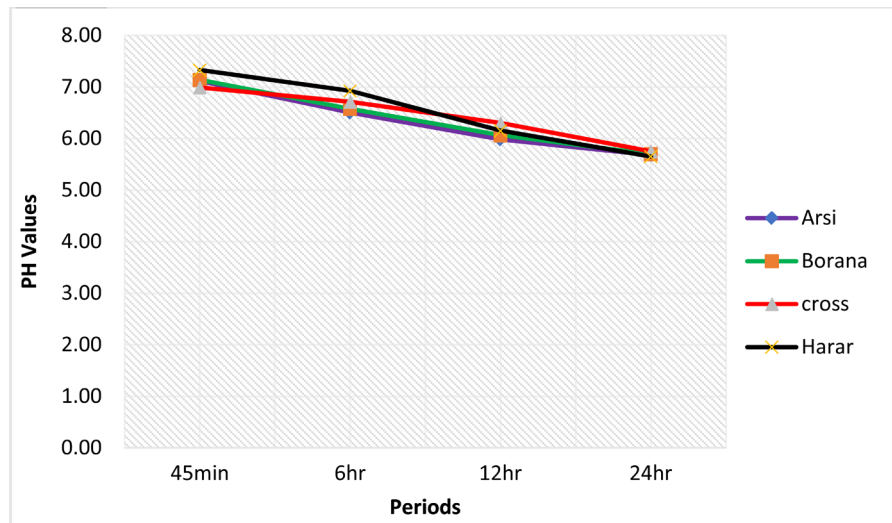
The pH value has a significant impact on the color, shelf life, taste, microbiological stability, yield and texture of meat and meat products and is, therefore, important for meat quality evaluation [44]. MSA research has found beef with pH levels above 5.70 to be of lower and more variable eating quality. Accordingly, 5.70 has been set as the maximum pH level for MSA grading. In line with eating quality, the acceptable range of pH was 5.30 - 5.70 [45] [46]. Carcass pH of Arsi, Borana, Harar and HF-Cross bulls were presented in **Figure 2** and **Figure 3**. The result of this study shows that the longissimus dorsi muscle pH value was decreased linearly with almost comparable rate in all breeds starting from 45 minute after slaughter up to 24 hours to achieve ultimate pH in case of both LDM and Semitendinosus muscle. The minimum ultimate pH was recorded for Harar (5.5) whereas the maximum value for Borana (5.70) in LDM. This result is

**Table 9.** Prediction of meat yield from live trait and primal cuts.

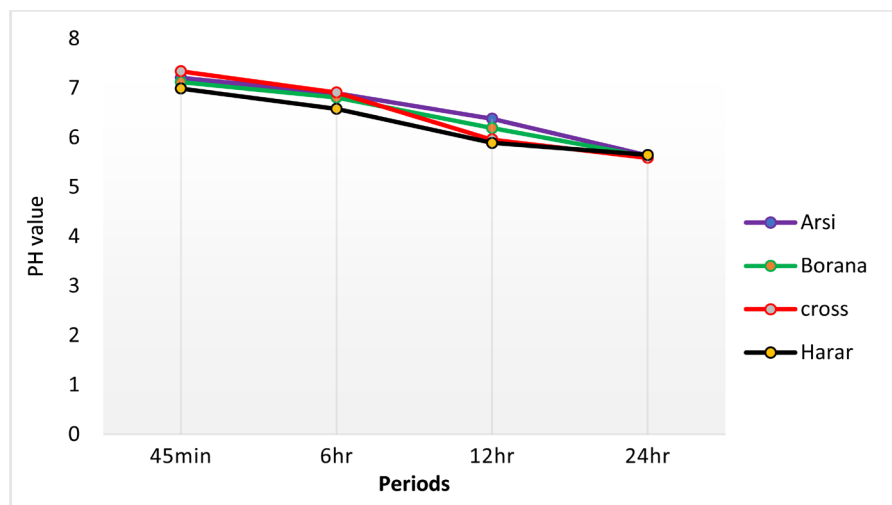
	Models	R <sup>2</sup> (%)	MSE	P-Value
Live Animal traits	$Y = -0.0744 + 0.191(\text{SBW})$	84.29	2.92	***
	$Y = -8.05 + 0.182(\text{SBW}) + 1.51(\text{BCS})$	89.56	2.43	***
Primal cuts	$Y = 13.03 + 1.82(\text{ch})$	84.08	2.93	***
	$Y = 25.86 + 2.45(\text{rib})$	32.86	6.03	**
	$Y = 18.28 + 13.41(\text{plt})$	67.33	4.21	***
	$Y = 18.35 + 18.02(\text{tln})$	71.81	3.91	***
	$Y = -5.97 + 3.80(\text{rd})$	59.23	4.70	***
	$Y = 8.62 + 1.04(\text{ch}) + 0.87(\text{rib}) + 2.56(\text{plt}) + 5.10(\text{tln}) + 0.23(\text{rd})$	94.78	1.86	***

Y = meat yield (kg), SBW = slaughter body weight, BCS = body condition score, ch = Chuck, plt = plate, tln = tender loin, rd = round,  $R^2$  = coefficient of determination, MSE = mean square error.





**Figure 2.** Longissimus dorsi muscle pH.



**Figure 3.** Semitendinosus muscle pH.

in line with the finding of [47] for different Ethiopian indigenous cattle breeds, [16] for the same breeds with the current study. Regarding Semitendinosus muscle  $pH_u$  the minimum was recorded for HF-Cross (5.59) while the maximum value for Harar (5.65). This indicates that the ultimate pH value in the current study in both LDM and Semitendinosus muscle were found within the normal range (5.30 to 5.70) for tropical beef [44]. Therefore, transporting Arsi, Borana, HF-Cross and Harar bulls within the average ambient temperature ( $^{\circ}\text{C}$ ), relative humidity (%), speed (km/hr), journey distance (km), and total time spent on the truck, 25.5, 51.85, 462, and 14 hrs respectively and giving a rest for 62 hours before slaughter did not stress the animals and also did not influence meat quality.

#### 4. Conclusion

From the study, it was concluded that the HF-cross and Borana bulls produced better total edible proportion. This further indicates the need to exploit dairy



beef in addition to local cattle breeds. Concentrate supplementation improves meat yield percent of bulls from local cattle and cross breeds as compared with some previous literature on indigenous cattle in Ethiopia. Supplementing Arsi bulls with age of above five years old is not economically profitable in terms of meat yield percentage as compared with Borana, Harar and HF-Crossbred bulls. Live weight and body condition score in addition to major primal cuts could be reliable measurement in estimation of meat yield.

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### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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