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Ethiopian beef carcass characteristics

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This study was conducted to evaluate beef carcass characteristics of cattle slaughtered at local abattoirs in Ethiopia. About 10% of carcasses (3080) were collected from Adama, Hawassa, Mekelle and Kombolcha abattoirs between August 2013 and January 2014. The results of the study showed that 98.56% of cattle slaughtered were indigenous cattle while 1.44% was Holstein Frisian. The average carcass weight of indigenous cattle was 135.90 + 0.69 kg. Carcass weight was significantly ($p<0.001$) different between abattoirs, season, conformation grades, fat grades and categories of cattle. Conformation grade 1, 2 and 3 accounted for 30, 34.29 and 35.71% of carcasses evaluated, respectively. Fat grade1, 2 and 3 accounted for 67.5, 23.57 and 8.93% of carcasses evaluated, respectively. Intact bulls, castrated bulls, growing bulls and cows accounted for 26.07, 64.64, 3.95 and 5.36% cattle slaughtered, respectively. Higher carcass weight, higher proportion of superior conformation and fat grade were observed in the wet season compared to the dry season. Inferior conformation and fat grades were relatively higher for cows (80 and 84.42%) and castrated bulls (37.57 and 67.96%) compared to other categories of cattle. From the study it was concluded that the use of dairy beef was very low in Ethiopia. The proportion of carcass with little /no fat cover (fat grade 1) was very high. The relatively better carcasses weight, conformation and fat grades in the wet season compared to the dry season indicates the opportunities to improve carcass weight and quality through better feeding management.

Key words: Beef carcass weight, conformation and fat grades, local abattoirs, Ethiopia.

INTRODUCTION

Livestock plays an important role in the agriculture of Ethiopia. It contributes 15 to17% of gross domestic product (GDP) and 35 to 49% of agricultural GDP (CSA, 2008). Cattle contribute about 80% of GDP that come from livestock (Tefera, 2011). Ethiopia has 53.4 million cattle (CSA, 2011) which represent the largest cattle population in Africa (Negassa et al., 2011).

However, the potential has not been fully utilized. Cattle in Ethiopia produced about 0.331 million tones of meat annually (CSA, 2008). Average carcass weight of cattle was 108 kg/head (Negassa et al., 2011), while Ethiopians consume about 8 kg of meat per capita annually which is far less than what is consumed in developing countries (Betru and Kawashima, 2009).

There is no specialized production system specifically for beef production in Ethiopia. Beef is a by-product in the

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Table 1. Descriptions of the study area.

Abattior	Region	Distance from Addis (km)	Global position	Altitude (MASL)	T°C	RF (mm)
Adama	Oromiya	99 E	8°32'N 39°16E	1712	13 - 27	809
Hawassa	SPNN	250 S	7°03'N 38°28E	1500 - 2000	20 - 25	800 -1000
Kombolcha	Amhara	375 NE	11°4'N 39°44E	1842 - 1915	11 - 26	750 - 900
Mekelle	Tigray	783 N	7°13'N 5°52E	2000 - 2200	11- 24	579-650

MASL, Meters above sea level; mm, millimeters; SPNN, Southern people national and nationalities.

pastoral and mixed crop-livestock production system as cattle are primarily kept for milk and traction purposes, respectively. Cattle are usually sold when they are culled from dairy purpose, too old for draft purpose and usually in a poor body condition. Pastoral, agro-pastoral and mixed crop-livestock production systems accounted for more than 99% of cattle production system practiced in the country (Negassa et al., 2011).

Very little research has been done concerning meat production in Ethiopia (Avery, 2004), and in particular, on carcass quality of beef cattle (Negassa and Jabbar, 2008). Even though Ethiopia has developed a beef carcass classification system in 2012 (ES, 2012), the system was not used to characterize the carcass quality to date. Characterizing carcass traits of cattle is important to develop an appropriate improvement strategy of the sector. Moreover, the tendency to pay beef producers based on carcasses quality and weight is increasing. Carcass quality is mainly determined by age, sex, conformation and fat cover (Lazzaroni and Biagini, 2009). Different proportion of categories of cattle, conformation grade and fat grade were reported for different abattoirs in different countries (Lazzaroni and Biagini, 2009; Weglarz, 2010; Savell et al., 2011).

The objective of this study was therefore to evaluate carcass characteristics of cattle slaughtered at local abattoirs in Ethiopia.

MATERIALS AND METHODS

Study abattoirs

The study region contained more than 95% of cattle population of the country that is, Oromiya - 23 million, Amhara - 13.4 million, SPNN - 11 million and Tigray- 3.6 million (CSA, 2011). The dominant cattle breed slaughtered at Adama and Hawassa abattoirs were Arsi and Bale cattle breeds, while at Kombolcha and Mekelle abattoirs Raya, Wollo highland, Arado and Barka breeds were slaughtered. All cattle slaughtered were produced form mixed crop-livestock production system. However, most cattle supplied to Adama abattoirs were fattened in the feedlot for some period after being purchased from farmers in mixed crop-livestock/agro-pastoral production system. Trekking is common method of transporting cattle to abattoirs. Even though stunning boxes were available at the abattoirs, it was not seen being used in the processes of slaughter. Based on the information from the workers, cattle are not willing to enter into the boxes. Stunning of cattle was made by stubbing sharp knife at attlanto-occipital space. Evisceration took place at the floor by incising the skin at the ventral and central part of the abdomen. Then cattle were hoisted with their hind legs for further processing. It is common to quarter carcasses and transport to butcheries. No refrigeration is used at abattoirs as hot carcasses are supplied to market for consumers. Description of the study areas are shown in Table 1.

Data collection

Information on categories of cattle slaughtered, gender, hot carcass weight, conformation and fat grades, sanitary condition and coat color of the hide were collected from the study abattoirs. Data was collected during 7 to 10 days from 10% cattle slaughtered in each abattoir in the dry and the wet season between August, 2013 and January, 2014. The country has short rainy (March-May), long rainy (June-September) and dry (October-February) seasons.

Conformation and fat scores were recorded by an inspector at all abattoirs studied to avoid subjective difference between evaluators using the standards shown in Table 2. Carcasses were evaluated during slaughtering process on hot carcasses. Half right side of whole carcasses was weighted using a scale sensitive at 100 g. The weight of half right side was multiplied by 2 to estimate whole carcass weight. Carcasses were categorized into cows, growing bulls, intact bulls and castrated bulls based on physiological age (degree of ossification of cartilage of thoracic vertebrae, discs of intervertebral sacral vertebrae) and sex of cattle slaughtered (Table 2). Data was collected on sanitary conditions on the hide of the cattle using mud score technique (Boleman et al., 1998). For the purpose, mud score 0 was given for cattle with no mud; mud score 1 for cattle with mud on legs and mud score 2 for cattle with mud on legs and belly. Data was collected on the hide color of cattle. Hide color were classified based on primary color (>50% total hide surface area) into black, white, red, gray or Holstein Frisian.

Statistical analysis

Data were analyzed using JMP version 8 statistical software. Factors showing significant difference at probability level of $p < 0.05$ were compared using Tukey pairwise comparison procedure. Carcass weight was analyzed using conformation, fat, category and abattoirs as fixed effects. The percentage of different grades of conformation and fat of carcasses was calculated as a ratio of carcasses in each category to the total carcasses evaluated.

RESULTS AND DISCUSSION

Coat color of cattle slaughtered at Adama, Hawassa and Mekelle abattoirs

The coat colors of cattle slaughtered at local abattoirs are

Table 2. Characteristics and description beef carcass classification (ES) system in Ethiopia (ES, 2012).

Conformation	Grade
Carcasses with convex profiles and very well developed muscle	1
Carcasses with straight profiles and good muscle development	2
Carcasses with concave profiles and moderate muscle development	3
Fat	**Grade**
Carcasses with small or no fat coverage	1
Carcasses with visible fat on the whole body with the exception the hind leg and shoulder	2
Whole carcasses covered with fat and fat deposited in the thoracic cavity	3
Descriptions	**Categories**
Carcass of young bull or heifers that weight less than 70 kg	JB
Carcasses of grown up bulls (cartilage of the spine up to four thoracic vertebras show no sign of ossification and from fifth to ninth show sign of ossification; discs of inter-vertebral of sacral vertebrae show sign of ossification)	JM
Carcasses of intact bulls (not castrated; all cartilage of the spine of thoracic vertebras ossified)	M
Carcasses of castrated bulls (castrated; all cartilage of the spine of thoracic vertebras ossified)	O
Carcasses of heifers (undeveloped udder; all cartilage of the spine of thoracic vertebras ossified)	JF
Carcasses of cows (well developed udder; all cartilage of the spine of thoracic vertebras ossified)	F

Table 3. Coat color of cattle slaughtered at local abattoirs.

Abattoirs	Coat color					Total
	>50% Black (%)	>50% Gray (%)	Holstein Frisian (%)	>50% Red (%)	>50% White (%)	
Overall	748 (32.54)	451 (19.62)	33 (1.44)	737 (32.06)	330 (14.35)	2299
Adama	330 (29.41)	275 (24.51)	11 (0.98)	341 (30.39)	165 (14.71)	1122
Hawassa	176 (41.03)	99 (23.08)	0 (0.00)	132 (30.77)	22 (5.13)	429
Mekelle	242 (32.35)	77 (10.29)	22 (2.94)	264 (35.29)	143 (19.12)	748

$\chi^2 = 138.99$; $p<.0001$.

presented in Table 3. The coat colors of cattle slaughtered during the study period were black, gray, red and white. The difference in the proportion of coat colors between abattoirs indicates the difference in cattle breeds slaughtered at the abattoirs studied. Holstein Frisian cattle account for 1.44% of cattle slaughtered. Most of cattle slaughtered at the abattoirs were indigenous local cattle. The dairy industry is rapidly growing in Ethiopia (Hutcheson, 2006). The present study further confirmed the report by Hutcheson (2006) which suggested the need to exploit dairy beef in Ethiopia.

Carcass weight between abattoirs, season, conformation, fat grades and categories of cattle

Carcass yield difference between abattoirs, season, conformation grades, fat grades and categories of cattle are presented in Table 4. The average carcass weight at local abattoirs was 135.90 ± 0.69 kg. The average carcass weight in the present study was comparable to the report for Boran (98.2 to 135.2 kg) and Ogaden (163 to 182 kg) cattle at research station in Ethiopia and relatively higher than the carcass weight of WASH (74.1 kg) and Sanga (95.3 kg) cattle in Ghana (Lemma et al., 2007; Teye and Sunkwa, 2010; Mekasha et al., 2011). Carcass weight was significantly ($p < 0.001$) different between abattoirs, season, conformation grades, fat grades and categories of cattle slaughtered. Relatively higher carcass weight was observed in Adama abattoir (161.26 ± 1.05 kg) compared to Hawassa (142.46 ± 1.10 kg) and Mekelle (136.15 ± 1.17 kg) abattoirs. Cattle slaughtered in Kombolcha abattoir had relatively lower carcass weight which was 95.63 ± 0.46 kg. The difference in carcass weight, conformation and fat grade between abattoirs studied in the present study might be

Table 4. Carcass weight between abattoirs, season, conformation and fat grades and categories of cattle.

Variable	Number of observation	%	Mean (kg)	SE
Overall mean	3080		135.90	0.69
Abattoir				
Adama	1122	36.43	161.26[a]	1.05
Hawassa	429	13.93	142.46[b]	1.10
Kombolcha	781	25.36	95.63[d]	0.46
Mekelle	748	24.29	136.15[c]	1.17
Season				
Dry	1661	53.93	119.56[b]	0.89
Wet	1419	46.07	155.02[a]	0.83
Conformation grade				
1	924	30.00	171.24[a]	1.04
2	1056	34.29	130.39[b]	0.85
3	1100	35.71	111.51[c]	0.89
Fat grade				
1	2079	67.50	120.69[c]	0.70
2	726	23.57	162.59[b]	1.09
3	275	8.93	180.44[a]	1.80
Category				
Cow (F)	165	5.36	103.10[c]	2.24
Growing bull (JM)	121	3.93	132.36[b]	2.57
Intact bull (M)	803	26.07	150.90[a]	1.34
Castrated bull (O)	1991	64.64	132.78[b]	0.83

Means in the same column with different superscript letters differ ($p < 0.001$).

due to the difference in breed and environment in which cattle was managed prior to slaughter. A large proportion of fattening centers is found in and around the city Adama (Little et al., 2010) which serve as source of cattle for the Adama abattoir. Most of cattle slaughtered at Mekelle and Kombolcha abattoirs were supplied directly by the farmers (without going through fattening).

A higher carcasses weight was observed in the wet season (155.02 ± 0.83 kg) compared to the dry season (119.56 ± 0.89 kg). This might be due to the availability of feed and water in wet season which made the cattle finished in good body condition and relatively better slaughter weight. Conformation grade 1 had relatively higher carcass weight (171.24 ± 1.04 kg) compared to conformation grade 2 (130. 39 ± 0.85 kg) and conformation grade 3 (111.51 ± 0.89 kg). This might be due to the better muscle development of carcasses categorized as conformation grade 1 over carcasses categorized in conformation grade 2. The difference in carcass weight between conformation 2 and conformation grade 3 can be explained similarly. Moreover, the significant effect of conformation on carcass weight was well observed in Table 4. Conformation grades 1, 2 and 3 accounted for 30, 34.29 and 35.71% of carcasses evaluated, respectively. The lower proportion of superior conformation and higher proportion of inferior conformation were similarly reported in some other research conducted using SUEROP classification system (Lazzaroni and Biagini, 2009; Méndez et al., 2009; Petroman et al., 2009). Fat grade 3, carcasses had relatively higher weight (180.44 ± 1.80 kg) compared to fat grade 2 carcasses (162.59 ± 1.09 kg) and fat grade 1 carcasses (120.69 ± 0.70 kg). This can be due to the cover of the whole carcasses with fat in grade 3 compared to fat grade 2. Fat grade 1 had little/no fat covering the carcasses. Fat grades 1, 2 and 3 accounted for 67.5, 23.57 and 8.93% of carcasses evaluated, respectively. The proportions of little/no fat carcasses were relatively higher in this study. This indicated that the carcasses produced currently in Ethiopia did not satisfy the consumer preference as Ethiopian prefers high fat meat (Aynalem et al., 2011). Moreover, adequate fat cover must be present to produce corresponding marbling that determines quality of the

product. The higher proportion of fat grade 1 in the present study was in contrary to the finding in northern Italy where higher proportion of fat grade 2 carcasses was observed (Lazzaroni and Biagini, 2009). According to these researchers, the higher proportion of fat grade 2 reflects the preference of the consumers for low fat meat. The higher proportion of little/no fat carcasses in the present study might be associated with poor body condition of cattle prior slaughter. Feed shortage was often reported as a major constraint to livestock production in Ethiopia. Natural pasture is the main source of feed for most livestock, complemented by fodder and crop residues during the dry season. Productivity of the rangeland was about 0.15 ton/ha (Halderman, 2004).

In the present study, the proportion of intact bulls, castrated bulls, growing bulls and cows accounted for 26.07, 64.64, 3.95 and 5.36% of carcasses evaluated, respectively. The higher proportion of castrated bulls might be due to the practice of farmers in mixed crop-livestock production system to castrate bulls. It was this system which supplied most cattle for abattoirs studied. The proportion of intact bulls slaughtered at local abattoirs in the present study was less than the proportion reported in Poland, which was about 47% (Weglarz, 2010). No carcasses from immature bulls and heifers were encountered during the study period. This is in contrast to the carcasses produced in USA namely 87.3% bulls and heifers less than 2 years of age (Savell et al., 2011). In contrary to the present finding, about 46.46, 24.69, 15.16 and 13.04% of intact bulls, cows, veal calves and other females, respectively, were slaughtered in north-west Italy (Lazzaroni and Biagini, 2009). Increasing the number of young animals slaughtered is one way of increasing the quality of carcass as the age of the animal is one of the factors affecting carcass quality (Toro et al., 2009; Morales et al., 2012). Farmers should be advised to sell their cattle at young stage. Creating paying market for young cattle encourage farmers to sell excess young animals. In addition to production of quality carcass from young cattle, selling excess young animals will reduce stocking density on the farms. By reducing stocking density on the farm, the body condition of available herd will be maintained in good condition. In the present study, intact bulls had relatively higher mean carcass weight (150.90 ± 1.34 kg) compared to castrated bulls (132.78 ± 0.83 kg), growing bulls (132.36 ± 2.57 kg) and cows (103.10 ± 2.24 kg)(Table 4). The reason for lower carcass weight of castrated bulls and cows compared to intact bulls in the present study might be the old age and poor body conditions of these cattle at time of slaughter as they have been serving for the draft and milking purpose, respectively, before they were used for beef purpose. Intact bulls were usually slaughtered at a young age. Higher carcass weights from intact bulls compared to castrated bulls and cows in present study were similarly reported for Hanwoo cattle in Korean (Park et al., 2002).

Conformation and fat grades of carcasses at Adama, Hawassa, Mekelle and Kombolcha abattoirs

Carcass conformation of cattle slaughtered in Adama, Hawassa, Mekelle and Kombolcha abattoirs is presented in Table 5. A relatively higher proportion conformation grade 1 carcass (superior conformation) was observed in Adama local abattoirs (57.84%) compared to Hawassa (35.90%) and Mekelle (16. 04%) with mean carcass weights of 176.32 ± 1.19, 157.79 ± 1.31 and 161.09 ± 3.95 kg, respectively. No carcass with conformation grade 1 was observed at Kombolcha abattoir. Conformation grade 2 carcasses were relatively higher at Hawassa (45.92%) and Mekelle (44.25%) abattoirs compared to Kombolcha (33.80%) abattoir with carcass weights of 138.14 ± 1.42 kg, 137.60 ± 1.29 kg and 100.29 ± 0.70 kg, respectively. This conformation grade was relatively lower at Adama abattoir (22.46%) with carcass weight of 151.89 ± 1.50 kg. Conformation grade 3 (inferior conformation) were relatively lower at Adama (19.70%) and Hawassa (18.18%) abattoirs compared to Mekelle (39.71%) abattoir with carcass weight of 127.58 ± 2.23 kg, 138.14 ± 2.94 kg and 124.37 ± 1.65 kg, respectively. This conformation grade was relatively higher at Kombolcha abattoir (66.20%) with carcass weight of 93.26 ± 0.57 kg. Proportion of superior and inferior conformations corresponds to heavier and lighter carcass weights, respectively. After all, in local market in Ethiopia, price of live cattle was determined based on conformation as weighting scale was rarely used.

A relatively lower proportion of fat grade 1 carcasses were observed at Adama (28.43%) compared to Hawassa (61.54%) abattoir with the mean carcass weights of 139.48 ± 1.91 and 133.83 ± 1.21 kg, respectively. However, almost all carcasses evaluated at Mekelle (95.59%) and Kombolcha (100.00%) abattoirs were fat grade 1 with the mean carcass weights of 134.49 ± 1.19 and 95.63 ± 0.46 kg, respectively. The proportion of fat grade 2 carcasses at Adama was relatively higher (51.96%) compared to Hawassa abattoir (28.44%) with mean carcass weights of 165.29 ± 1.26 and 148.27 ± 1.98 kg, respectively. The proportion of the same fat grade was very low at Mekelle abattoirs (2.81%) with mean carcass weights of 170.00 ± 0.44 kg. The proportion of fat grade 3 carcasses at Adama and Hawassa were 19.61 and 10.02% with mean carcass weights of 182.15 ± 2.19 and 173.00 ± 2.20 kg, respectively. The proportion of this fat grade was very low at Mekelle abattoirs (1.60%) abattoir with mean carcass weights of 176.00 ± 1.23 kg. No fat grades 2 and 3 carcasses were observed at Kombolcha abattoir during the study period. The explanation made for the difference in carcass weight between abattoirs studied hold true for the difference in conformation and fat grade between abattoirs. Moreover, similar to conformations of carcasses, fat cover had significant role in determining the weight of carcasses as heavier weight corresponds to

Table 5. Conformation and fat grades of carcasses at local abattoirs.

Abattoirs	Conformation					Fat				
	Grade*	Carcass number	%**	Mean weight (kg/ carcass)	SEM	Grade***	Carcass number	%**	Mean weight (kg/carcass)	SEM
Adama	1	649	57.84	176.32^{a}	1.19	1	319	28.43	139.48^{c}	1.91
	2	252	22.46	151.89^{b}	1.50	2	583	51.96	165.29^{b}	1.26
	3	221	19.70	127.58^{c}	2.23	3	220	19.61	182.15^{a}	2.19
Hawassa	1	154	35.90	157.79^{a}	1.31	1	264	61.54	133.83^{c}	1.21
	2	197	45.92	138.14^{ab}	1.42	2	122	28.44	148.27^{b}	1.98
	3	78	18.18	131.06^{b}	2.94	3	43	10.02	173.00^{a}	2.20
Mekelle	1	120	16.04	161.09^{a}	3.95	1	715	95.59	134.49^{b}	1.19
	2	331	44.25	137.60^{ab}	1.29	2	21	2.81	170.00^{a}	0.44
	3	297	39.71	124.37^{b}	1.65	3	12	1.60	176.00^{a}	1.23
Kombolcha	1	0	0.00	-	-	1	781	100.00	95.63	0.46
	2	264	33.80	100.29^{a}	0.70	2	0	0.00	-	-
	3	517	66.20	93.26^{b}	0.57	3	0	0.00	-	-

*1, Superior conformation; 2, moderate conformation; 3, inferior conformation; **, proportion of carcasses in each conformation/fat categories; ***1, carcass with little/no fat; 2, fat cover whole body except hind leg and shoulder; 3, fat cover the whole body; Means in the same column with different superscript letters differ ($p < 0.001$).

Table 6. Conformation and fat grades of carcasses in the wet and the dry season.

Season	Conformation					Fat				
	Grade*	Carcass number	%**	Mean weight (kg/ carcass)	SEM	Grade***	Carcass number	%**	Mean weight (kg/ carcass)	SEM
Wet	1	616	43.41	173.91^{a}	1.20	1	682	48.06	143.31^{c}	1.08
	2	494	34.81	143.04^{b}	1.49	2	473	33.33	157.63^{b}	1.24
	3	309	21.78	138.98^{b}	1.01	3	264	18.60	180.63^{a}	1.87
Dry	1	309	18.60	165.90^{a}	1.96	1	1397	84.11	109.48^{b}	0.73
	2	549	33.05	122.67^{b}	1.28	2	250	15.05	171.87^{a}	1.98
	3	803	48.34	99.38^{c}	0.70	3	14	0.84	176.00^{a}	2.10

*1, Superior conformation, 2, moderate conformation; 3, inferior conformation; **, proportion of carcasses in each conformation/fat categories; ***1, carcass with little/no fat; 2, fat cover whole body except hind leg and shoulder; 3, fat cover the whole body; Means in the same column with different superscript letters differ ($p < 0.001$).

superior fat disposition. After all, some researchers define conformation as thickness of muscle, intramuscular fat and subcutaneous fat relative to the dimension of the skeleton (De Boer et al., 1974). The finding in this study further indicated the need to develop different strategy by different region in fattening cattle before slaughter as conformation and fat grade significantly different from region to region the abattoirs are located.

Conformation and fat grades of carcasses in wet and dry seasons

Conformation and fat grades of carcasses in the wet and dry season is presented in Table 6. Conformation grade 1 (superior conformation) was relatively higher in the wet season (43.41%) with heavier carcass weight of 173.91 ± 1.20 kg compared to the dry season (18.60%) with carcass weight of 165.90 ± 1.96 kg. The proportion of conformation grade 2 was comparable in the wet (34.81%) and the dry season (33.05%) with carcass weights of 143.04 ± 1.49 and 122.67 ± 1.28 kg, respectively. Conformation grade 3 (inferior conformation) were relatively higher in the dry season (48.34%) with the average carcass weight of 99.38 ± 0.70 kg compared to the wet season (21.78%) with the average carcass weight of 138.98 ± 1.01 kg.

A relatively smaller proportion of fat grade 1 carcasses

Table 7. Conformation grades of different categories of cattle.

Categories*	Conformation					Fat				
	Grade**	Number of carcass	%***	Mean carcass weight (kg/carcass)	SEM	Grade****	Number of carcass	%***	Mean carcass weight (kg/carcass)	SEM
Cows (F)	1	21	12.73	140.25^{a}	3.00	1	130	84.42	96.37^{b}	2.30
	2	12	7.27	126.00^{a}	2.50	2	24	15.58	130.00^{a}	3.79
	3	132	80.00	95.00^{b}	2.24	3	0	0.00	-	-
Growing bull (JM)	1	56	46.28	150.40^{a}	2.53	1	65	65.66	126.25^{b}	3.12
	2	42	34.71	121.50^{b}	2.84	2	24	24.24	138.00^{ab}	3.70
	3	23	19.01	115.25^{b}	1.96	3	10	10.10	154.00^{a}	3.93
Intact bull (M)	1	308	38.36	176.98^{a}	1.89	1	495	62.50	136.40^{c}	1.46
	2	285	35.49	139.35^{b}	1.45	2	230	29.04	172.45^{b}	2.04
	3	210	26.15	128.29^{c}	2.62	3	67	8.46	189.17^{a}	4.32
Castrated bull (O)	1	540	27.12	171.35^{a}	1.31	1	1353	67.96	116.77^{c}	0.80
	2	703	35.31	127.77^{b}	1.10	2	441	22.15	160.29^{b}	1.29
	3	748	37.57	109.40^{c}	0.87	3	197	9.89	179.89^{a}	1.88

*JM, Carcass of grown up bull; M, carcass of mature intact bulls; O, carcass of castrated bulls; F, carcass of cows; **1, Superior conformation; 2, moderate conformation; 3, inferior conformation; ***, proportion of carcasses in each conformation/ fat in each category; ****1, carcass with little/no fat; 2, fat cover whole body except hind leg and shoulder; 3, fat cover the whole body; Means in the same column with different superscript letters differ ($p < 0.001$).

were observed in the wet season (48.06%) with a mean carcass weight of 143.31 ± 1.08 kg compared to the dry season (84.11%) with a mean carcass weight of 109.48 ± 0.73 kg. Relatively higher proportion of fat grade 2 carcasses were observed in the wet season (33.33%) compared to the dry season (15.05%) with carcass weights of 157.63 ± 1.24 and 171.87 ± 1.98 kg, respectively. Moreover, a relatively higher proportion of fat grade 3 carcass was observed in the wet season (18.60%) compared to the dry season (0.84%) with mean carcass weights of 180.63 ± 1.87 and 176.00 ± 2.10 kg, respectively. The explanation made for the difference in carcass weight between the wet and dry seasons hold true for the difference in conformation and fat grade between seasons. The finding in this study further indicated the need to develop strategy of supplementing cattle in the dry season to produce higher yield and quality carcasses.

Conformation and fat grades in different categories of cattle

The conformation and fat grades of different categories of cattle are presented in Table 7. A relatively higher proportion of conformation grade 3 (inferior conformation) was observed in cows (80.00%) with carcass weight of 95.00 ± 2.24 kg compared to conformation grade 1 (12.73%) and conformation grade 2 (7.27%) with carcass weights of 140.25 ± 3.00 and 126.00 ± 2.50 kg, respectively. Moreover, higher proportion of conformation grade 3 (37.57%) was observed in castrated bulls compared to the conformation grade 1 (27.07%) with carcass weights of 109.40 ± 0.87 and 171.35 ± 1.31 kg, respectively. However, the proportion of conformation grade 1 were relatively higher in growing bulls (46.28%) and intact bulls (38.36%) with carcass weights of 150.40 ± 2.53 and 176.98 ± 1.89 kg, respectively compared to the proportion of conformation grade 3 which were 19.01 and 26.03% with carcass weights of 115.25 ± 1.96 and 128.29 ± 2.62 kg, respectively.

The proportion of fat grade 1 carcasses were relatively higher in all categories of cattle that is, 84.42% of cows, 65.66% of growing bulls, 62.50% of mature intact bulls and 67.96% of castrated bulls with carcass weights of 96.37 ± 2.30, 126.25 ± 3.12, 136.40 ± 1.46 and 116.77 ± 0.80 kg, respectively. This indicated the slaughter of all categories of cattle without developing enough fat cover. The development of fat cover corresponds to the proportion of fat with in muscle (marbling) which affect the quality of meat significantly. Hence, it is important to let cattle develop enough fat cover before slaughter. The present study indicated the need to improve the body condition of cattle before slaughter. Appropriate feeding at producer level or prior to slaughter in a feedlot is the only way to improve the quality of the carcasses. Long-term strategy should be developed to improve feed resources at mixed crop-livestock production system. At present condition, cattle produced by small farmers need to be fatten in feedlot for short period prior to slaughter.

Table 8. Mud score of cattle slaughtered at local abattoirs.

Factor	Mud score* (%)			Total	χ2	p-value
	0	1	2			
Overall mean	1903 (82.78)	341 (14.83)	55 (2.39)	2299		
Abattoir					573.247	<0.0001
Adama	990 (88.24)	132 (11.76)	0 (0.00)	1122		
Hawassa	187 (43.59)	187 (43.59)	55 (12.82)	429		
Mekelle	726 (97.06)	22 (2.94)	0 (0.00)	748		
Season					338.556	<0.0001
Dry	869 (98.75)	11 (1.25)	0 (0.00)	880		
Wet	1034 (72.87)	330 (23.26)	55 (3.88)	1419		

*0, No mud; 1, mud on leg; 2, mud on leg and belly.

Fat grade 2 carcasses produced from 15.58% cows, 24.24% growing bulls, 29.04% intact bulls and 22.15% castrated bulls with mean carcass weights 130.00 ± 3.79, 154.00 ± 3.93, 172.45 ± 2.04 and 160.29 ± 1.29 kg, respectively. Fat grade 3 carcasses were produced from 10.10% growing bulls, 8.46% intact bulls and 9.89% castrated bulls with mean carcass weights of 154.00 ± 3.93, 189.17 ± 4.32 and 179.89 ± 1.88 kg, respectively. Fat grade 3 carcass was not observed in the category of cows during the study period. The explanation made for lower carcass weights of cows and castrated bull can apply to the difference in conformation and fat grades of these categories of cattle in the present study. This further confirms the fact that the culled cows were in a very poor condition when they were slaughtered. Higher age at slaughter was reported as one of the reason for poor quality of carcass from cows (Zaujec et al., 2012). Feeding cull cows is a viable option to improve yield and quality grade of carcasses. Some studies reported that cull cows can gain tremendous amounts of weight in relatively short times on high-grain diets (Pritchard and Berg, 1993; Funston et al., 2003). Cow fed for shorter durations was reported more likely to experience more rapid gains (Faulkner et al., 1989). However, it should be noted that cull cows are not efficient in a feedlot and need to have every possible management strategy to maximize feed conversion efficiency.

Mud score of cattle slaughtered at local abattoirs

Mud score of cattle slaughtered at local abattoirs is presented in Table 8. Of all the cattle scored for mud, 82.78% had score of 0 (no mud), 14.83% had score of 1 (mud on leg) and 2.39% had sore 2 (mud on leg and belly). Mud or manure on the skin of animal are the main sources of contamination of carcasses, especially when it is present on the legs and belly of the animal and when there is a hide opening which may introduce this contamination to the carcass (Hanson, 2000). Hence, it is important to develop strategy to minimize mud/manure on the skin before processing animal for meat. Mud scores 1 and 2 were relatively higher in Hawassa (43.59 and 12.82%) compared to cattle slaughtered at Adama (11.76 and 0.00%) and Mekelle (2.94 and 0.00%) abattoirs. Mud scores 1 and 2 were relatively higher in wet season (23.26 and 3.88%) compared to the dry season (1.25 and 0.00%). The difference in sanitations of the skin between abattoirs reflects the difference in management of cattle and level of moisture in different regions. This suggests the need to develop strategy to minimize mud/manure on the hide, particularly, at those abattoirs this problem was relatively high and during wet season. The proportion of cattle with no mud and mud on legs in the present study was comparable to the reported in USA which was 61.6 and 18.8%, respectively. However, the proportion of cattle with mud on leg and belly was relatively lower than the report in USA which was 14.5% (Boleman et al., 1998). This might be due to the difference in number of cattle supplied to abattoirs at a time. In Ethiopia, butcheries brought cattle to abattoirs to get slaughter service which was usually less than five cattle per butchery at a time, while in USA large size of cattle were supplied at a time which might be difficult to control the sanitation of each and every animal. Furthermore in country like USA, cattle are supplied directly from the farm to the abattoirs, while in Ethiopia cattle go through different market structure to reach the destined abattoir. Traders might usually clean their cattle as dirt can divert the attention of the buyers looking for good body condition and conformation. The relatively higher mud score in wet season compared to the dry season in the present study might be the soiling of the skin of animal in the former than the latter season because of the wet ground.

Correlation and regression between conformation, fat and carcasses weight

The correlations between fat and conformation grades, carcass weight and conformation grade, and carcass

Table 9. Prediction of carcasses weight from conformation and fat grades.

Equation	R^2 (%)	P-value	
		Conformation	Fat
$y = 151 - 21.0\ x_1 + 19.8\ x_2$	46.9	**	**
$y = 197 - 29.5\ x_1$	38.9	**	-
$y = 88.1 + 33.8\ x_2$	32.8	-	**

** $p < 0.001$; y, carcass weight; x_1, comformation grade; x_2, fat grade.

weight and fat grade were significant ($p < 0.001$) with the correlation value of -0.535, -0.624 and 0.573, respectively. As the conformation of carcasses progress from inferior (grade 3) to superior (grade 1) and the fat grade progressed from low fat (grade 1) to high fat (grade 3), the weight of carcasses had increased from lighter to heavier. This further confirms the significant effect of conformation and fat grade on carcass weight. Similar to the present study, significant correlation value of 0.34 and 0.58 were reported between conformation and carcass weight in Brazil and Spain (Mendizábal, 2006; Cancian et al., 2013).

The prediction of carcass weight from conformation and fat grade is presented in Table 9. The carcass weight was significantly predicted from conformation grade, fat grade and the combination of the two. The coefficient of determination (R^2) indicated that conformation and fat grades predicted carcass weight at lower precision. However, R^2 relatively higher when the carcass weight was determined from combination of conformation and fat grade (46.9%) compared to conformation grade (38.9%) and fat grade (32.8%) separately.

Conclusion

Carcass weight of cattle slaughtered in local abattoirs in Ethiopia was comparable to cattle slaughtered in tropical part of Africa. However, the proportion of carcass with little/no fat was very high. Moreover, the proportion of inferior conformation and fat grades of cows and castrated bulls were relatively higher compared to other categories of cattle. The relatively better carcasses weight, conformation and fat grades in the wet season compared to the dry season indicates the opportunity to improve carcasses weight, conformation and fat grade through better feeding management.

ETHICAL APPROVAL

Permission was obtained from ethical committee of University of Pretoria to carry out the present study.

Conflict of Interest

The authors declare that there is no conflict of interest.

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