Effect of Age and Body Condition on Slaughter Characteristics of Dromedary Camels (*Camelus dromedarius*) in Eastern Ethiopia

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Abstract

A study was conducted to investigate the effect of age and body condition on slaughter yield characteristics of Issa-Somali camels. One-hundred and forty camels were divided into 3 age groups: group 1 (6-10 years), group 2 (11-17 years), and group 3 (≥ 18 years). Each age group was then divided into a further three sub-groups according to the body condition score (BCS) of camels. These sub-groups were poor, medium, and good. Age, BCS, live weight (LW), and weight of carcass and non-carcass components were determined by dentition, notations on fat status, linear body measurements, and weighing using a hanging scale, respectively. The mean slaughter LW was 334.7 kg. The weight of hot carcass (HCW), edible non-carcass product yield (ENPY), inedible non-carcass product yield (INPY), total consumable product yield (TCPY), and total slaughter weight (TSW) were 186.4, 28.9, 110.7, 215.3, and 326.0 kg, respectively. The dressing-out percentage was 55.5% implying camels as producers of high proportion of meat under extensive management. The LW, HCW, ENPY, INPY, TCPY, and TSW significantly ($P<0.05$) increased with increasing age and improving BCS. The forequarter (29.1%) was heavier than hindquarter (22.7% of TSW) due to the presence of a hump and neck. The variation was however insignificant ($P>0.05$). Heart and lung were not affected ($P>0.05$) by age and BCS. The yield components significantly and positively correlated with each other and to LW. Thoracic girth was the most reliable predictor of LW and yield components in regression equations. Camels of 11-17 year-old from medium body condition had the optimum slaughter characteristics compared to other groups. Options should be sought to utilize and add value to INPY that comprised 33.1% of LW of camel.

Keywords: carcass yield, consumable product, dressing-out percentage, non-carcass product, slaughter weight

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Introduction

Ethiopia has 4.5 million heads of dromedary camels (*Camelus dromedarius*) (Shapiro et al., 2015) and the eastern part of the country is the major camel distribution area (Yohannes et al., 2012). Camels are reared under extensive systems on poor levels of nutrition and mostly slaughtered at old ages after completing a career in physical work, racing or milk production (Kadim et al., 2013). Under the extensive system, herders keep all age groups of camels (the young as replacement stock and the mature for reproduction) and play multipurpose roles in the community. Meat production is the main product derived from camels under extensive management in areas where the climate adversely affects other animals' production efficiency (Kadim et al., 2008). Thus, camel meat could be a good option to meet the growing needs for meat in arid and semi-arid environments of developing countries (Saparov and Annageldiyev, 2005).

The carcass and non-carcass characteristics of camels are affected by different factors such as condition of the animal, breed, age, sex, fatness, dressing procedures, and degree of gut fill at slaughter (Skidmore, 2005). Body condition, conformation, age, and sex were the most important traits influencing selection of livestock for export in Somali markets (Mugunieri et al., 2012). Nutritional status and body size were reported as synonymous to body condition and conformation, respectively (Negassa et al., 2008; Mugunieri et al., 2012). Conformation is correlated to age and body condition of the animal. Although camels in Ethiopia are kept under extensive system of production, the management practices vary from herder to herder and across localities. For this reason, camel performances or body conditions vary accordingly. Camels also have long life span of up to 35 years (Abebe, 1991). Due to the vast heterogeneity in age and body condition, yield of camel meat is highly variable. Thus, age and body condition are considered to be among the important traits for camels as meat animals for domestic and export markets. In general, the export market requires male rather than female livestock (cattle, small ruminants, and camels; Mugunieri et al., 2012) while local abattoirs use both sexes. Even so, the majority of the animals used for slaughter are males.

Body condition is an important trait assessed by animal buyers. For animals that need to travel long distances, such as for the purposes of the export market, fatty animals with extreme body condition scores are not a priority choice of buyers due to high risk of mortality, particularly in shipments of long journey. On the other hand, lean animals have little reserve fat so are unable to withstand stresses (Gaden, 2005). In relation to this, the MoARD (2008) of Ethiopia has recommended camels for export to have body condition scores of 2 to 4 (inclusive) on a scale of 1 to 5.

The Dire Dawa municipality abattoir is one of the abattoirs in the country where camels of different ages and body conditions are frequently slaughtered for local consumption. However, there is lack of information regarding the effects of age and body condition on carcass and non-carcass characteristics of camels. The objective of this study was, therefore, to investigate the effects of age and body condition on carcass and non-carcass characteristics of camels at slaughtered Dire Dawa abattoir.

Materials and Methods

Description of the study area

The study was carried out at Dire Dawa town municipality abattoir, eastern Ethiopia where camels that mainly originated from Shinile district and Dire Dawa administration were slaughtered. The altitude of the town is 1180 m.a.s.l. In reference to African Rainfall Climatology (ARC) satellite data of 1983 to 2015 (inclusive), the mean annual rainfall was 680.5 mm. A 20-year data (1996-2015) from Meteorological Agency of Ethiopia indicated that the minimum and maximum temperatures were 18.8 °C and 32.1 °C respectively.

Experimental animals and treatments

Data were collected from 140 Issa-Somali camels slaughtered at Dire Dawa municipality abattoir. The camels were of varying ages and body conditions which originated from Shinile district (94.0 or 67.1%) and Dire Dawa administration (46.0 or 32.9%) (Table 1). Two factors were considered in our study: the age of the camels, with the camels being grouped into three age groups according to their chronological age at the time of slaughter as “group 1” (6-10 years), “group 2” (11-17 years), and “group 3” (≥ 18 years); and, three body condition groups (poor, medium, and good). The 2 factors each with 3 levels were arranged in a 3 × 3 two-way factorial Completely Randomized Design (Factorial CRD).

Table 1. Number of camels used in the study

Age		**Body Condition Score**			**Total**
Group	**Range (years)**	**Poor**	**Medium**	**Good**	
Group 1	6-10	9	8	7	24
Group 2	11-17	27	11	14	52
Group 3	≥ 18	28	18	18	64
	Total	64	37	39	140

Age estimation and assessment of body condition score

According to the abattoir's routine practice, camels were deprived of water and feed for an average of 24 and 12 hours at the awaiting area, locally called Jellaba, after which they were taken to the abattoir for slaughter. Age and body condition score (BCS) of each camel were recorded prior slaughter. Age was determined based on dentition (Payne and Wilson, 1999; Bello et al., 2013) and substantiated by information from an experienced person (Khan et al., 2003). Scores of 1 to 5 (1 = very lean, 2 = below average, 3 = average or ideal, 4 = above average, and 5 = very fat) have been adopted to assess BCS (Gaden, 2005). Notations of the fat status of spinous and transverse processes of vertebra, hollow of flank, and ribs (Faye et al., 2001); and measurements of hump height and chest depth (Gaden, 2005; MoARD, 2008) were used to score body condition. The qualitative notations described by Faye et al. (2001) were used with slight modification. For ribs, the scales were 1 = individually visible, 2 = slightly visible, 3 = intermediate, 4 = not very visible, and 5 = not visible; for spinous and transverse processes of vertebrae, 1 = very prominent, 2 = prominent, 3 = intermediate, 4 = slightly prominent, and 5 = not visible; and for hallow of flank, 1 = very visible, 2 = visible, 3 = intermediate, 4 = slightly visible, and 5 = not visible. The notations were performed by visual observation and manual palpation (Faye et al., 2001). The camels were categorized into three condition groups as 'poor' (BCS of 1 to 2), 'medium' (BCS of 3) and 'good' (BCS of 4 to 5) (Robinson, 2010).

Estimation of live body weight

The live body weight of camels was estimated from linear measurements of girth (chest and hump) and shoulder height using the formula described by Younan et al. (2012). This formula entailed that body weight (kg) is equal to SH × TG × HG × 50, where SH is equal to shoulder height measured vertically from the ground to the tip of the scapula using a graduated stick of 2.5 m height with a movable bar at right angle, TG is equal to thoracic girth in meters using a tape around the body just behind the sternal pad, and HG is equal to hump girth in meters using a tape along the abdomen over the midpoint of the hump. The linear measurements were taken early in the morning when the animals were starved for at least 12 hrs in the awaiting area so as to reduce measurement variability.

Slaughtering procedure and yield measures

Camels were slaughtered following the routine slaughtering procedure of the abattoir under veterinary inspection. The slaughtering began by cutting the Achilles tendons, followed by cutting the base of the neck where major vessels are well exposed. Following the slaughtering and complete bleeding, all the feet were severed at the knee and hock joints followed by a severing of the head and neck and skinning of the neck cut. Skinning or flaying began at the back in a crouching position and continued downwards on both sides to the belly. The flayed hide remained on the ground under the belly until dissection of all cuts was completed. Following skinning, the hump fat, front leg to the shoulder tip, the loin, ribs, kidneys, backbone, gastrointestinal tract, internal organs (liver, lung, and heart), brisket, tail, hindlegs, and hide were dissected based on the traditional dissection procedures at the abattoir and butcheries. Dissecting required that the carcass be divided into forequarter and hindquarter between the 12th rib and 1st lumbar vertebrae. A hanging scale of 100 kg (Model NTA, Camry, China) was used to weigh all fresh carcass and non-carcass components to the nearest 0.1 kg. The total non-carcass product yield (TNPY) comprised of the edible non-carcass product yield (ENPY) and the inedible non-carcass product yield (INPY). The total consumable products yield (TCPY) was the sum of hot carcass weight (HCW) and ENPY. The total slaughter weight (TSW) was comprised of TCPY and INPY. The dressing-out percentage (DOP) was subsequently computed as percentage of HCW to live body weight.

Statistical analysis

The experimental design was a two-way factorial in a complete randomized design (Factorial-CRD). The model of the study was:

$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + E_{ijk}$, where

Y_{ijk} = the response variable

μ = overall mean

A_i = the i^{th} age effect

B_j = the j^{th} body condition effect

$(AB)_{ij}$ = the interaction between the i^{th} age and j^{th} body condition

E_{ijk} = random error

Data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS version 9.1 (SAS, 2008), using PROC means to compare the effect of age and body condition on carcass and non-carcass components. Least squares means were separated by PROC GLM with the PDIFF option of SAS for treatments with significant effect at P<0.05 by employing Tukey's multiple comparison procedure. Results were reported as least squares means with accompanying standard error. Pearson's multiple linear correlation and regression analyses were performed using the same software to determine the extent of relationship among variables.

Results

Linear body measurements, live weights and dressing-out percentages

Mean values (± standard errors) of the estimated weights from linear body measurements, hot carcass yields, and dressing-out percentages (DOP) of slaughtered camels are summarized in Table 2. The age of camels had significant (P<0.001) effect on shoulder height (SH), thoracic girth (TG), hump girth (HG), live weight (LW), and hot carcass weight (HCW), but did not affect DOP. The values of all these variables increased with age. Accordingly, camels of age groups 2 and 3 showed significantly (P<0.001) higher values than camels of group 1. With exception of SH, body condition score (BCS) of camels affected the variables indicated in Table 2. The TG (P<0.01), HG (P<0.003) and LW (P<0.008) of camels with good condition were significantly higher than camels with medium and poor condition groups. The HCW varied significantly (P<0.0001) among body condition groups where camels at good condition scored the highest value, and the DOP of poor-conditioned camels was significantly (P<0.0001) lower than the other two body condition groups.

Carcass and non-carcass yields

The carcass and non-carcass components are summarized in Tables 3, 4 and 5. Camel age had a significant effect (P<0.001) on HCW, edible non-carcass product yield (ENPY), inedible non-carcass product yield (INPY), total consumable product yield (TCPY), and total slaughter weight (TSW) where camels from groups 2 and 3 had higher values than camels from group 1 (Table 3). The TSW, TCPY, HCW, ENPY, and INPY of camels from age group 3 were heavier than those from age group 1 by 30.1, 30.4, 30.6, 29.3, and 29.5%; and, those from age group 2 were heavier than group 1 by 24.8, 25.7, 3.5, 5.6, and 5.1%, respectively. This study further indicated that the carcass and non-carcass components of dromedary camels were affected by body condition. The HCW, TCPY, and TSW of camels varied significantly (P<0.001) under the three body condition groups, with camels at good body condition scoring the highest values. The ENPY of good and medium body conditioned camels was significantly (P<0.001) heavier than camels of poor condition group (Table 3). For INPY, camels of good condition group had significantly (P<0.01) higher values than those from medium and poor body conditioned groups.

Table 2. Linear measurements (m), estimates of live weights and hot carcass weights (kg), and dressing-out percentages (%) of camels slaughtered at Dire Dawa abattoir

Variables	Linear Measurements			Live Weight (LW)	Hot Carcass Weight (HCW)	Dressing-out % (DOP)
	Shoulder Height (SH)	Thoracic Girth (TG)	Hump Girth (HG)			
Age group (A)						
Group 1	1.73±0.02[b]	1.73±0.02[b]	1.84±0.03[b]	278.4±11[b]	153.68±7.21[b]	55±1.14[a]
Group 2	1.80±0.01[a]	1.88±0.02[a]	2.02±0.02[a]	343.2±8[a]	193.93±5.03[a]	56.1±0.7[a]
Group 3	1.80±0.01[a]	1.91±0.01[a]	2.04±0.02[a]	357.0±6.7[a]	200.68±4.46[a]	56.3±0.8[a]
Body condition group (B)						
Poor	1.77±0.01[a]	1.80±0.02[b]	1.90±0.02[b]	305.0±7.1[b]	161.99±4.67[c]	53.3±0.7[b]
Medium	1.78±0.01[a]	1.83±0.02[b]	1.95±0.03[b]	321.7±8.9[b]	182.77±5.90[b]	56.7±0.9[a]
Good	1.78±0.01[a]	1.89±0.02[a]	2.05±0.03[a]	352.0±8.75[a]	203.51±5.79[a]	57.9±0.9[a]
A × B	ns	ns	ns	ns	ns	ns
Overall values						
Range	1.42-2	1.37-2.22	1.4-2.45	145.9-544	61.14-323.99	44.2-69.4
Mean±SE	1.79±0.01	1.86±0.01	1.99±0.02	334.7±5.28	186.4±3.56	55.5±0.5
CV	4.71	6.03	8.08	15.94	18.93	9.98

[a,b,c] Means with the same letter superscripts in the same column for each treatment factor are not significantly different (P<0.05); group 1 (6-10 year-old), group 2 (11-17 year-old) and group 3 (≥ 18 year-old); ns = not significant.

Table 3. Effect of age and body condition score on carcass and non-carcass weights (kg) of camels slaughtered at Dire Dawa abattoir.

Factors	Edible Components		Inedible Non-carcass Product Yield (INPY)	TCPY = HCW + ENPY	Total Slaughter Wt. (TSW) = TCPY + INPY
	Hot Carcass Weight (HCW)	Edible Non-carcass Product Yield (ENPY)			
Age group (A)					
Group 1	153.67±7.21[b]	24.08±0.92[b]	91.57±3.46[b]	177.75±7.99[b]	269.32±11.16[b]
Group 2	193.93±5.03[a]	29.49±0.64[a]	112.79±2.41[a]	223.42±5.58[a]	336.21±7.78[a]
Group 3	200.68±4.46[a]	31.13±0.57[a]	118.59±2.14[a]	231.81±4.94[a]	350.39±6.90[a]
Body condition group (B)					
Poor	161.99±4.67[c]	26.06±0.59[b]	101.30±2.24[b]	188.06±5.18[c]	289.36±7.23[c]
Medium	182.77±5.90[b]	28.30±0.75[a]	105.13±2.83[b]	211.08±6.55[b]	316.21±9.14[b]
Good	203.51±5.79[a]	30.33±0.74[a]	116.52±2.78[a]	233.84±6.42[a]	350.36±8.96[a]
A × B	ns	ns	ns	ns	ns
Overall values					
Range	61.14-323.99	10.64-41.21	52.25-181.59	71.78-362.74	126.37-544.33
Mean±SE	186.4±3.56	28.92±0.45	110.7±1.71	215.33±3.97	326.03±5.57
CV	18.93	15.51	15.30	18.18	16.76

[a,b,c] Means with the same letter superscripts in the same column for each treatment factor are not significantly different (P<0.05); TCPY = total consumable product yield; group 1 (6-10 year-old), group 2 (11-17 year-old) and group 3 (≥ 18 year-old); ns = not significant.

The major edible parts of the carcass were categorized into forequarter and hindquarter. The weight of each quarter significantly (P<0.001) increased with age and improving body condition score of the camels. This may be due to an increase in physical and/or chemical maturity (Table 4).

Age and body condition of the camels had a significant effect on most of the ENPY and INPY components with higher values obtained with increases in age and towards good body condition of camels (Table 5). The intestines of the camels were significantly (P<0.01) affected by the age of camels, but not by their body condition. Following the removal of the skin and viscera, the carcasses were divided into commercial cuts according to the abattoir standard practice and market requirements.

Coefficients of correlation among variables and regression equations

Although the correlation values between the variables studied varied, a positive correlation was found between most of the variables (Table 6). With the exception of dressing-out percentage (DOP), the variables in Table 6 used to estimate carcass and non-carcass components were significantly and positively related to the linear body measurements (shoulder height or SH, thoracic girth or TG and hump girth or HG), with the strongest correlation being with that of TG (r ≥ 0.8). The live weight (LW) of camels had significant (P<0.001) positive correlation with TG (r = 0.95), followed in order by its correlation with HG (r = 0.93) and SH (r = 0.80). The LW was significantly correlated to total slaughter weight (TSW), ENPY and INPY.

Table 4. Mean (±standard error) weights (kg) of major carcass cuts of camels.

Major Cuts	Age group			Body condition group		
	Group 1	Group 2	Group 3	Poor	Medium	Good
Forequarter	77.32±4.3^{b}	96.88±3.1^{a}	103.09±2.7^{a}	81.12±3^{c}	92.77±3.6^{b}	104.65±3.6^{a}
Neck	13.9±0.9^{b}	18.7±0.6^{a}	20.1±0.6^{a}	16.4±0.6^{b}	17.5±0.7^{ab}	19±0.7^{a}
Front legs	42.6±2.2^{b}	53.3±1.5^{a}	55.4±1.3^{a}	44.7±1.4^{c}	50.3±1.8^{b}	56.4±1.7^{a}
Hump	3.8±0.6^{b}	5.6±0.4^{a}	4.3±0.4^{b}	2.8±0.4^{c}	4.5±0.5^{b}	6.35±0.5^{a}
Ribs	8.18±0.5^{b}	8.98±0.3^{a}	10.29±0.3^{a}	8.31±0.3^{b}	9.67±0.4^{a}	10.5±0.4^{a}
Brisket	8.84±0.5^{b}	11.6±0.4^{a}	11.7±0.3^{a}	8.91±0.3^{c}	10.8±0.4^{b}	12.4±0.4^{a}
Hindquarter	61.22±3.1^{b}	76.02±2.3^{a}	80.11±1.9^{a}	64.72±2.2^{b}	72.64±2.6^{b}	79.96±2.6^{a}
Hind legs	42±1.9^{b}	51.5±1.3^{a}	54.5±1.2^{a}	44.5±1.2^{c}	49.5±1.6^{b}	54±1.5^{a}
Loin	14.2±0.7^{b}	18.4±0.5^{a}	19.3±0.5^{a}	15.2±0.5^{c}	17.2±0.6^{b}	19.5±0.6^{a}
Flank	5.02±0.3^{b}	6.12±0.2^{a}	6.31±0.2^{a}	5.09±0.2^{b}	5.93±0.2^{a}	6.46±0.2^{a}

[a,b,c] Means with the same letter superscripts in the same row under each treatment factor are not significantly different (P<0.05); group 1 (6-10 year-old), group 2 (11-17 year-old) and group 3 (≥ 18 year-old).

Moreover, the carcass and non-carcass components were significantly correlated to each other. The correlation of LW to the linear body measurements was slightly higher than the correlations of HCW, ENPY, INPY, TCPY, and TSW to each of the respective linear body measurements (Table 6). However, there was a weak relationship between DOP and HG. Moreover, a weak correlation was observed between DOP and the linear body measurements SH and TG as well as with LW since DOP has an inverse relationship to these variables.

Gaden (2005) and MoARD (2008) described hump height (HH) as a proportion of chest depth (CD) to assess body condition score (BCS) of camels. The correlation analysis performed between HH, CD, hump yield (HY), and the BCS values assessed based on the notations of the fat status of anatomical places revealed a significantly (P<0.001) positive and strong relationship between HH and HY (r = 0.81). Despite this, only a mild relationship (r = 0.19 to 0.49) was observed between any other variable pairs (Table 7).

Table 5. Mean (± standard error) weight (kg) of major edible and inedible non-carcass components.

Non-carcass	Age group			Body condition group		
Components	Group 1	Group 2	Group 3	Poor	Medium	Good
Edible	21.21±0.8[c]	25.9±0.6[b]	27.24±0.5[a]	22.8±0.6[b]	24.88±0.7[ab]	26.59±0.7[a]
Liver	5.2±0.3[b]	6.1±0.2[a]	6.4±0.2[a]	5.3±0.2[b]	6.1±0.3[a]	6.3±0.3[a]
Heart	1.8±0.1[a]	2±0.09[a]	2±0.08[a]	1.8±0.08[a]	2±0.1[a]	2±0.1[a]
Stomach	5.35±0.3[b]	6.64±0.2[a]	6.69±0.2[a]	5.82±0.2[b]	6.18±0.2[ab]	6.69±0.2[a]
Head	8.76±0.4[c]	11.16±0.3[b]	12.15±0.3[a]	9.9±0.3[b]	10.6±0.4[b]	11.6±0.4[a]
Inedible	91.47±3.5[b]	112.78±2.5[a]	118.62±2.2[a]	82.51±2.4[b]	86.12±2.9[b]	95.95±2.9[a]
Feet	12±0.6[b]	14.8±0.4[a]	15.6±0.4[a]	13.4±0.4[b]	13.7±0.5[b]	15.3±0.5[a]
Lung	1.8±0.13[a]	1.8±0.09[a]	2±0.08[a]	1.84±0.1[a]	1.88±0.1[a]	1.94±0.1[a]
Hide	23.5±1.2[b]	30.2±0.8[a]	32±0.74[a]	26.3±0.8[b]	27.8±1[b]	31.7±0.9[a]
Spleen	0.53±0.03[b]	0.68±0.02[a]	0.7±0.02[a]	0.57±0.02[c]	0.64±0.02[b]	0.71±0.02[a]
Intestine	16.9±1[b]	19.8±0.7[a]	21±0.6[a]	18.5±0.8[a]	18.9±0.6[a]	20.4±0.8[a]
Blood	20.05±0.8[b]	24.7±0.5[a]	25.7±0.5[a]	21.9±0.5[b]	23.2±0.6[b]	25.3±0.6[a]
Rep. organ	0.39±0.02[b]	0.5±0.01[a]	0.52±0.01[a]	0.42±0.01[c]	0.48±0.02[b]	0.53±0.02[a]
Misc.	16.3±0.63[b]	20.3±0.44[a]	21.06±0.4[a]	17.96±0.4[b]	18.9±0.5[b]	20.7±0.5[a]

[a,b,c] Means with the same letter superscripts in the same row under each treatment factor are not significantly different (P<0.05); group 1 (6-10 year-old), group 2 (11-17 year-old) and group 3 (≥ 18 year-old).

Table 6. Coefficients of correlation among major slaughter characteristics of camels at Dire Dawa abattoir.

Variables	SH	TG	HG	LW	HCW	DOP	ENPY	INPY	TCPY	TSW
SH	1.00	***	***	***	***	*	***	***	***	***
TG	0.78	1.00	***	***	***	*	***	***	***	***
HG	0.57	0.84	1.00	***	***	ns	***	***	***	***
LW	0.80	0.95	0.93	1.00	***	*	***	***	***	***
HCW	0.74	0.87	0.80	0.90	1.00	***	***	***	***	***
DOP	0.19	0.20	0.09	0.17	0.58	1.00	***	***	***	***
ENPY	0.71	0.82	0.74	0.83	0.89	0.47	1.00	***	***	***
INPY	0.78	0.91	0.84	0.93	0.90	0.30	0.85	1.00	***	***
TCPY	0.74	0.87	0.81	0.90	0.99	0.57	0.91	0.91	1.00	***
TSW	0.77	0.90	0.83	0.93	0.99	0.50	0.91	0.95	0.99	1.00

SH = shoulder height; TG = thoracic girth; HG = hump girth; LW = live weight; HCW = hot carcass weight; DOP = dressing-out percentage; ENPY = edible non-carcass product yield; INPY = inedible non-carcass product yield; TCPY = total consumable product yield; TSW = total slaughter weight; ns = not significant; * = P<0.05; ** = P<0.01; *** = P<0.001.

Table 7. Correlation of hump height, chest depth, body condition score, and hump yield of Issa-Somali camels

Parameters	HH	CD	BCS	HY
Hump height (HH)	1.00			
Chest depth (CD)	0.41^{***}	1.00		
Body condition score (BCS)	0.37^{***}	0.19^{*}	1.00	
Hump yield (HY)	0.81^{***}	0.35^{***}	0.49^{***}	1.00

* = P<0.05; *** = P<0.001.

The extent of the relationship between the linear body measurements as explanatory variables and LW and yield components as response variables were explained in regression equations (Table 8). For all regression equations, the adjusted coefficient of determination (R^2) values were significant (P<0.01) in describing the relationships among predictor and response variables.

Discussion

Regardless of their body condition, camels from age groups 2 and 3 attained physical maturity and thus have higher SH than camels at lower age group with corresponding higher mean values for LW and HCW. In line with the current study, the increase in age accounted for an increase in LW. This can be seen as Najdi camels in Saudi Arabia grew from 171.2 kg at 8 months to 450.9 kg at 26 months of age

(Abouheif et al., 1991) and Butana camels in Sudan grew from 246.5 kg at 2 years to 356 kg at 4 years of age (Asma et al., 2014). In a similar study, Asma et al. (2014) found that HCW increased from 115.4 kg to 172.8 kg with increasing camel age. Abebe et al. (2002) found higher LW (425.9 kg) and HCW (233.4 kg) for Issa-Somali camels aged over 10 years. Kurtu (2004) also reported LW of 465.8 kg for male Jijiga camels which is higher than the LW of Issa-Somali camels in the current study. The difference may be due to large body size of the former breed. A wider range of carcass weight (125 to 400 kg) was reported for different types of camels with the variation apparently due to age, body condition, sex, and breed (Kadim et al., 2008).

Table 8. Predictive regression equations and coefficients of determination (R^2) describing the relationship between linear body measurements as explanatory variables and live weight, hot carcass weight, and total slaughter weight as response variables

Response variable	**Simple Linear Regression**		**Multiple Linear Regression**		
			Two variables		**Equation with three variables and R^2**
	Equation	**R^2**	**Equation**	**R^2**	
Live Weight (LW)	1. LW = -620.64 + 532.77*SH	0.64	1. LW = -573.17 + 103.5*SH + 388.41*TG	0.92	LW = -597.15 + 171.24*SH + 155.8*TG + 168.7*HG (R^2=0.92)
	2. LW= -493.26 + 445.21*TG	0.91	2. LW = -614.45 + 269.23*SH + 234.9*HG	0.97	
	3. LW = -288.28 + 313.77*HG	0.86	3. LW = -468.93 + 277.56*TG + 144.8*HG	0.96	
Hot Carcass Weight (HCW)	1. HCW = -404.3 + 329.43*SH	0.54	1. HCW = -375.21 + 66.04*SH + 238.31*TG	0.76	HCW = -385.1 + 94*SH + 142.3*TG + 69.64*HG (R^2=0.79)
	2. HCW = -324.2 + 274.56*TG	0.76	2. HCW = -400.91 + 183.5*SH + 130.06*HG	0.76	
	3. HCW = -178.6 + 183.83*HG	0.64	3. HCW = -314.72 + 209.14*TG + 56.49*HG	0.77	
Total Slaughter Weight (TSW)	1. TSW = -637 + 537.04*SH	0.59	3. TSW = -590.51 + 116.7*SH + 380.32*TG	0.82	TSW = -606.67 + 162.34*SH + 223.59*TG + 113.7*HG (R^2=0.85)
	2. TSW = -500.4 + 444.37*TG	0.81	4. TSW = -631.49 + 302.95*SH + 208.6*HG	0.82	
	3. TSW = -264.5 + 297.4*HG	0.69	5. TSW = -485.11 + 339*TG + 91*HG	0.83	

SH = Shoulder height; TG = Thoracic girth; HG = Hump girth

The increase in HCW towards good body condition is an attribute of increased energy reserves. This implies that camels with good body condition are dominant producers of a significant amount of meat, especially for local consumption. Camels at extreme body conditions should not be considered for export because well fattened camels may be exposed to injuries, metabolic disorder, or mortality during long transportation and poor conditioned camels are unable to withstand stresses (Gaden, 2005).

The lower DOP for camels from poor condition group was due to the higher estimated LW from linear measurements since the SH does not change once camels physically matured, regardless of the change in body condition. In using linear body measurements, there is a relative overestimation of the LW of physically matured tall and thin (poor conditioned camels), but an underestimation for short and good conditioned ones. This was the most probable reason for camels at poor condition group having lower DOP, given that the SH has slightly overestimated the LW to which the DOP was inversely related.

Dressing-out percentage is an important measure of yield in meat animals (Kadim et al., 2008). The mean DOP of 55.5% in the current study was high due to high carcass weight obtained from camels reared under extensive management system. A comparable DOP (52.8%) was reported by Abebe et al. (2002). Kadim et al. (2008) reported DOP of 55.9% and 54% in Sudanese male camels, and Salehi et al. (2013) found 60.3% and 58.8% in Iranian camels for hot and cold carcass weights, respectively. Kurtu (2004) reported DOP of 54.03% for male camels in Jijiga (Eastern Ethiopia). Abouheif et al. (1990) found no significant differences in DOP among 21 Najdi male camels slaughtered at 8, 16 and 26 months of age. Kadim et al. (2008) stated that age, weight, fatness, dressing procedures and degree of gut fill at slaughter to be among the factors causing variation in camels' DOP. The digestive tract content which is influenced by the duration of fasting until slaughter also causes variation in DOP of camels (Kadim and Mahgoub, 2013).

The increased weight of carcass and non-carcass components with increasing age and body condition of camels was mainly attributed to increased body weight at slaughter. The proportion of TCPY was as twice as the weight of the INPY. Regardless of quality traits, camels from age groups 2 and 3, and those from medium and good condition groups produced high amount of TCPY.

The hindquarter constitutes an important part of carcass meat because it contains large and tender muscle groups that determine the overall profit for butchers (Kadim and Mahgoub, 2013). The forequarter was heavier than the hindquarter mainly due to the presence of hump, neck and head which created a greater load on the forelegs that probably resulted in more muscled and heavier forelegs than hindlegs. Accordingly, the forequarter and hindquarter respectively comprised 29.07% and 22.74% of the TSW of camels. In accordance to the present study, Kurtu (2004) found the forequarter and hindquarter to comprise 29% and 20% of the total carcass weight, respectively. However, lower neck and higher hump weights were reported by Kurtu (2004) for Jijiga camels as compared to the present study. This was due to the breed difference as was confirmed by Yosef et al. (2013), where the Issa-Somali camels were smaller with light body weight but have muscled and prominent shoulder size than the Jijiga camel.

In the present study, the three cuts of the hindquarter indicated were similar to the cuts reported by Abouheif et al. (1990) and Kadim et al. (2008). Both authors noted that the forequarter was divided into six cuts: neck, shoulder, brisket, rib, hump, and plate. It should be noted that a slight difference was observed in carcass fabrication in the current study, given that the brisket and plate were dissected as a single cut, making the total cuts equal to five. The variation was due to the absence of standard cutting system for camel carcasses unlike for other meat animals (Kadim et al., 2008).

Both age and body condition score had no effect on heart and lung weight. This is likely due to the fact that these organs are vital for the physiology of animals and are developed fully at younger ages and thus show no weight change regardless of the change in age and body condition of camels. Asma et al. (2014) reported that weights of all body components increased with the age of camels with the exception of the lungs and heart which did not conform to this pattern.

Among the ENPY, the Issa-Somalis are given a high preference for their livers. The butchers in Dire Dawa town confirmed that camel products, particularly the hump and liver, carry a high demand among the Issa-Somalis for their perceived medicinal uses (besides the food value). Camels have proportionally heavier kidney (Al-Ani, 2004), which are twice that of cattle and four times that of sheep. This is possibly due to adaptation of the camel to arid environment (Kadim et al., 2008) and the larger size of the camel. The large liver in camels and the high preference to non-carcass edible component shows its economic value to the butchers.

The INPY that comprised one-third of the LW of slaughtered camels (110.7 kg or 33.07%) was merely disposed at the abattoir during the camel slaughter. The hide was the heaviest INPY with an average weight of 29.47 kg or 8.81% of the mean LW of camels (334.7 kg), followed by blood (24.1 kg or 7.2%), intestine (19.82 kg or 5.92%), and feet (14.53 kg or 4.34%). Regardless of body condition score, the weight of front feet (knee joint) was higher than the hind feet (hock joint) in each age group. This is probably due to the front legs being more muscular as they support heavier loads arising from the hump, neck, and head. Similarly, Asma et al. (2014) found higher weights in the front feet compared to the hind feet in each age group of Butana camels in Sudan. Comparable results were obtained for hide and feet by Herrman and Fischer (2004) in which they respectively contributed 7.3% and 3.4% of the LW of camels. However, Kurtu (2004) noted higher proportion for hide (15%). Breed differences, the nutritional state of the animal, and the slaughtering procedure may be responsible for variations between different studies.

In Ethiopia, camel head is usually consumed by low-income consumers. However, Kadim and Mahgoub (2013) stated that a camel's head was inedible, while the lungs and intestines were considered to be edible components. The differences may arise from cultural variations among consumers.

Data regarding the utility of non-carcass components of camels is lacking in the study area. Thus, the finding of the present study can contribute valid information to develop strategies for proper utilization of these products. In the rural parts of Ethiopia, the hide is used for bedding and to make prayer rugs and can also be used to make sandals. Camel hide can also be used to make ropes, drums, seats, traditional huts, baggage covers during migration and water and milk containers (Ahmed et al., 2003; Kagunyu and Wanjohi, 2014). Camel blood can be dried and used as a fertilizer (Blench, 2001) or as blood meal for animal feed.

The positive correlation (r = 0.95) between LW and thoracic girth (TG) indicated that TG had a strong influence in LW estimation of the camel breed. This is in agreement with the findings of Abebe et al. (2002) and Kuria et al. (2007), but was in contrast to the findings of Mungai et al. (2007). Mungai et al. (2007) found that the highest correlation was between LW and HG (r = 0.957), followed by TG (r = 0.934 and was the least correlative with SH (r = 0.432). This difference between the findings of Mungai et al. (2007) and the findings of other studies is probably due to age factors, given that only calves were considered in the former study. Yousif and Babiker (1989) found lower correlation between LW and TG (r = 0.67). The discrepancies in the findings among different studies is likely attributed to the variation in age, dody conditions and conformation of different breeds of camels.

In contrast to the present study, Abouheif et al. (1986) found higher correlations between carcass weight and linear body measurements than the correlations between LW and respective linear body measurements. The difference may be due to the variation associated with a difference in breed conformation. In general, estimation of LW from linear body measurements can also help estimate the carcass and non-carcass components prior to slaughter, provided that the correlations among different variables are determined for a particular breed of animal.

The present study indicated that the fatness of camels was not necessarily linked to hump height (HH) because HH was highly variable in all body condition score groups with better fat status while their anatomical features were characterised by a very small hump size . This was explained by the medium correlation (r = 0.37) between HH and BCS that was assessed based on the fat status of camels' anatomical features. This implies that assessment of BCS of Issa-Somali camels using measurements of HH in proportion to chest depth (CD) is not appropriate. Notations of anatomical features described by Faye et al. (2001) can be adopted. Similarly, Faye et al. (2001) found that the hump size was a less appropriate method to assess BCS.

For simple linear regression equations, those involving TG were the most appropriate predictors of LW, HCW, and TSW. The R^2 values of 0.91, 0.76, and 0.81 for these equations respectively indicate that 91%, 76%, and 81% of the variation in LW, HCW, and TSW can be attributed to TG. In these equations, TG was the most reliable predictor of LW, HCW, and TSW followed by equations involving HG and SH. For multiple regressions involving two explanatory variables, SH and HG were the most robust predictors for LW, whereas TG and HG were more appropriate for HCW and TSW. The multiple regression equations with two or three linear measurements best explained LW, followed by TSW then HCW. The HCW and TSW were best predicted by using all three linear measurement components than any of the equations involving one or two linear measurement components.

Conclusion

Camels, even under the extensive system, can be used to supply high quality protein to a large human population. Body weight and weight of carcass and non-carcass components were affected by the age and the body condition score of the camels. Live and slaughter weights of camels significantly increased with the increasing age of the animal. These parameters also increased with improving body conditions of camels in the same age group. For many of the variables, camels at 11-17 and ≥ 18 year-old, and those at medium and good body condition scores had comparable values in their respective groups. Camels between 11and 17 years of age with a medium body condition score had the optimum slaughter characteristics compared to other groups. Inedible non-carcass components should be added value to be utilised. The linear body measurements (SH, TG, and HG) can be used to estimate the live weight of Issa-Somali camels by employing the appropriate linear regression equations.

Acknowledgements

The authors acknowledge the Ministry of Education (MoE) of Ethiopia, Haramaya University, and Wollo University for their financial support to undertake this study. The cooperation received from the Dire Dawa municipality abattoir and butchers in Dire Dawa town is highly appreciated.

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