A STANDARD METHOD FOR JOINTING CAMEL CARCASSES WITH REFERENCE TO THE EFFECT OF SLAUGHTER AGE ON CARCASS CHARACTERISTICS IN NAJDI CAMELS. II. VARIATION IN LEAN GROWTH AND DISTRIBUTION

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Summary

The growth of lean from nine wholesale cuts in relation to the total lean weight in carcass side were evaluated with three allometric equations for 18 Najdi male camels slaughtered at 8, 16 and 26 months of age. The allometric growth coefficients indicated that as the camels grew, weights of lean from brisket and flank cuts increased relatively more rapidly than the total lean in carcass side ($\beta > 1.1$) and that weights of lean from wholesale shoulder and rump cuts increased relatively less rapidly ($\beta < .9$) than the total lean weight from carcass side. The growth coefficients for the lean in the thoracic limb and pelvic limb showed a dorsoventral rise in the growth impetus, with coefficients for the thoracic limb correspondingly higher than those of pelvic limb. The growth coefficients for the lean from shoulder, rib, flank and leg cuts increased ($p < .01$) with increased weight of total lean in carcass side, whereas it decreased with increased total lean weight in carcass side for the lean in neck, brisket, plate, loin and rump cuts. At a constant weight of total lean in carcass side, older camels had larger coefficients for lean in neck, brisket, rump, flank and leg cuts, but had smaller coefficients for lean in shoulder, rib, plate and loin cuts.
(Key Words: Camel Carcass, Lean Development, Slaughter Age, Allometric Growth)

Introduction

In meat animals, not only the total amount of lean is important but also its distribution, since large price differentials exist between wholesale cuts. As animals grow, the proportions of various muscles in the carcass change (Mukhoty and Berg, 1973; Berg and Butterfield, 1976). Many of the muscles of Merino sheep are shown to have biphasic growth patterns and no consistent topographical growth gradients (Lohse et al., 1971). Davies (1974) indicated that, porcine muscles reflect craniocaudal and distoproximal gradients. Fortin et al. (1980) found that the growth coefficients for muscle in the trunk and the thoracic and pelvic limbs of the cattle described a progressive rise in the growth impetus from the limbs to the trunk. These findings disagree with those of Berg et al. (1978) who observed several growth impetus waves that were centripetal on the limbs, caudocephalical on the whole body and dorsoventral on the trunk. However, the conflicts in the literature may result from different jointing procedures or to conformational differences between species. Since the growth and distribution of the lean in camel carcasses have not previously been described, the objective of this study was to examine the relative changes of lean among the standardized wholesale cuts of Najdi male camels slaughtered at 8, 16 and 26 months of age.

Materials and Methods

Eighteen Najdi male camels with average ages of 8, 16 and 26 months were selected randomly from the Najdi camel productivity project (AR-6-60) at King Saud University, Riyadh, Saudi Arabia, and assigned to three slaughter age groups of six animals each. The camel calves were creep fed on alfalfa hay and commercially formulated dairy calf starter concentrates (18% crude protein and 12.54 MJ ME/kg) and weaned at nine months of age. After weaning they were group fed on a diet at 2.1% of body weight. The diet was formulated to contain 9.86 MJ ME/kg and consisted of 40%

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alfalfa hay, 15% wheat straw and 45% commercial concentrate. Water, salt and mineral mixture were provided.

The camels were fasted 18 h before slaughter. Slaughtering was conducted at a commercial slaughterhouse, thereafter, carcasses were allowed to chill for 36 h at 10°C before splitting down the carcasses into right and left sides. Half carcasses were weighed and transported to the University Meat Laboratory, where the right side of the carcass (excluding kidney knob and pelvic fat) was jointed into nine standard wholesale cuts following the anatomical boundaries previously described by Abouheif et al. (1990). Each cut was physically separated into lean, fat and bone. For this study, total lean weight in the right side of the carcass was the sum of lean weights from all wholesale cuts.

The allometric equation, $Y = \alpha X^{\beta}$, as described by Seebeck (1968) was used to describe the increases in lean weight in each wholesale cut (Y) relative to the increases in carcass right side weight or total lean weight in the carcass right side (X). Growth coefficients (β) were obtained after the equation was converted to the logarithm function.

$$\text{Log } Y = \text{Log } \alpha + \beta \text{ Log } X \qquad \text{(model 1)}$$

The calculated β were used to classify the various growth impetus of the lean in wholesale cuts into the following three groups: positive growth impetus ($\beta > 1.1$), isometric growth impetus ($.9 \leq \beta \leq 1.1$) and negative growth impetus ($\beta < .9$). The possibility that growth coefficient (β) varied linearly with the independent variable (X) was tested by the model 2 (Notter et al.,1983), $Y = \alpha X^{b} e^{cX}$; $\beta = b + cX$, where e is the base of natural logarithms. Also the possibility that growth coefficient varied linearly with age (A) was tested with the model 3 (Turner, 1978), $Y = \alpha X^{b} e^{cX+dA}$; that $\beta = b + cX + dA$. Model 2 and 3 were converted to the logarithm functions as follows:

$$\text{Log } Y = \text{Log } \alpha + b \text{ Log } X + cX, \text{ and}$$

$$\text{Log } Y = \text{Log } \alpha + b \text{ Log } X + cX + dA, \text{ respectively.}$$

All statistical analyses were performed with the computer program entitled statistical analysis system (SAS, 1986).

Results and Discussion

Means and percentages for lean weight in carcass right side and in each wholesale cut by the three slaughtering ages are shown in table 1. Total lean weight in carcass side increased ($p < .01$) as the age of camel advanced from 8 to 26 months. However, the lean weight as a percent of carcass

TABLE 1. MEANS AND PERCENTAGES FOR LEAN WEIGHT IN EACH WHOLESALE CUT IN CARCASS RIGHT SIDE FROM NAJDI MALE CAMELS SLAUGHTERED AT DIFFERENT AGES (N = 6 ANIMALS / AGE GROUP)

Wholesale cut	Age (month)			SE	Age (month)			SE
	8	16	26		8	16	26	
	kg				%			
Neck	2.58^{a}	4.49^{b}	6.80^{c}	.25	55.3^{a}	60.8^{b}	63.6^{c}	3.1
Shoulder	5.97^{a}	7.99^{a}	10.54^{b}	.95	62.5^{b}	57.1^{a}	57.7^{a}	3.0
Brisket	2.95^{a}	7.02^{b}	13.08^{c}	1.01	47.6^{c}	56.0^{b}	62.9^{c}	2.9
Rib	2.19^{a}	3.42^{a}	5.64^{b}	.67	46.8^{c}	40.5^{b}	36.4^{a}	3.4
Plate	1.79^{a}	2.98^{b}	4.28^{c}	.21	50.0^{c}	42.9^{b}	35.2^{a}	1.8
Loin	2.12^{a}	3.44^{b}	4.92^{c}	.37	47.7^{b}	48.6^{b}	44.1^{a}	1.6
Rump	2.34^{a}	3.30^{ab}	4.29^{b}	.49	57.5	57.9	58.9	2.4
Flank	$.61^{a}$	1.05^{a}	1.97^{b}	.29	60.0^{b}	61.1^{b}	47.6^{a}	3.0
Leg	7.58^{a}	12.08^{b}	19.07^{c}	.98	65.5^{a}	67.6^{a}	70.4^{b}	4.0
Total side	28.12^{a}	45.77^{b}	70.59^{c}	3.04	56.3	55.9	55.6	2.3

^{a,b,c}Means in a row with different superscripts differ ($p < .01$).

side weight was not significantly affected by the age of camel and tended to be constant as the age increased. Lean weight in each cut changed significantly ($p < .01$) as age increased. These changes were most pronounced in wholesale brisket and flank cuts, increasing by 4.4 and 3.2 times, respectively, while both the rump and shoulder cuts changed the least, increasing only by 1.8 times. The effect of age on lean percent in each cut showed a variable trends among the studied wholesale cuts. However, lean percent in neck, brisket and leg cuts increased ($p < .01$) with age, whereas lean percent in rump cut did not change as age advanced. The remaining cuts decreased ($p < .01$) as the camel age increased from 8 to 26 months. Furthermore, the distribution percentages of total lean weight in cold carcass right side among the various wholesale cuts are shown in figure 1. As age increased from 8 to 26 months, there were an increase ($p < .01$) in the lean percent of brisket and flank cuts, expressed as a percentage of total lean in carcass side, and a decrease in lean percent of shoulder and rump cuts. On the other hand, lean percent in the other cuts were not affected by slaughter age. These results are in agreement with the findings by Berg et al. (1978) who found that muscle proportions in flank and brisket cuts relative to total muscle weight in bovine carcasses were increased with age. In general, the values obtained for the proportion of total lean distributed among the wholesale cuts in the carcass right side showed a major differences between camel and cattle or sheep carcasses. This may indicate a true species differences or it may simply reflect the differences in the anatomical boundaries of wholesale cuts.

The choice of the independent variable (X) in the allometric models, namely carcass side weight or total lean weight in carcass side, showed little to no difference in the growth coefficients (β) of lean

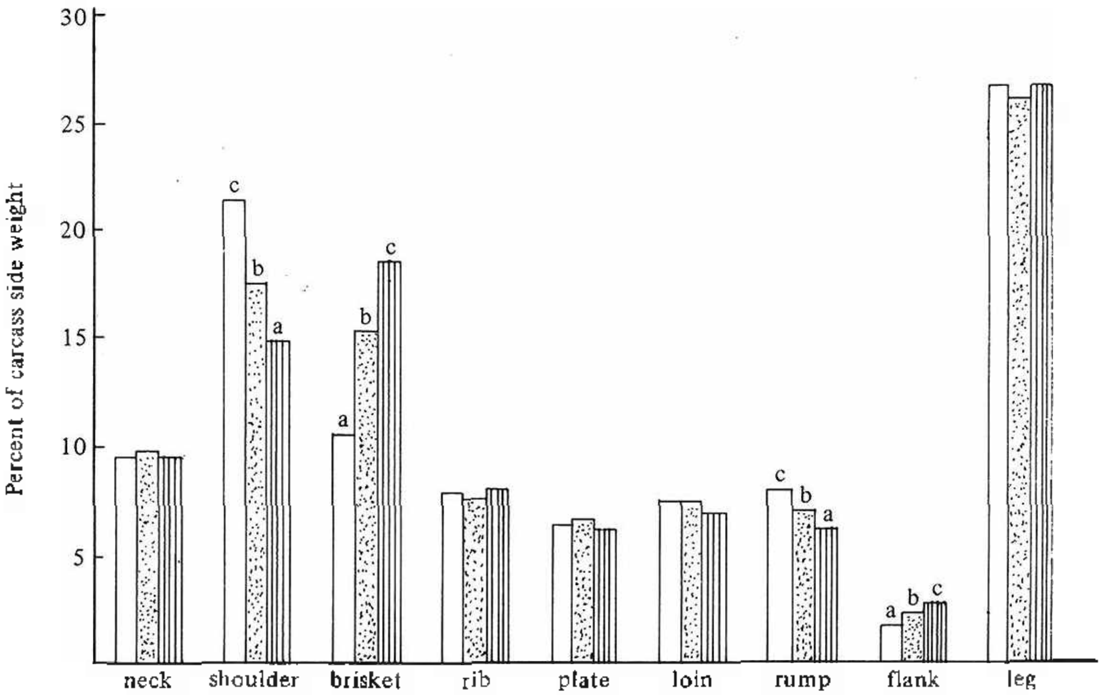

Figure 1. The distribution percentages of total lean weight in carcass right side among the wholesale cuts from Najdi male camels at different ages; □ 8 months of age, ▨ 16 months of age and ▥ 26 months of age. Column within each wholesale cut with different superscripts differ ($p < .01$).

between the two analyses. Therefore, only the growth coefficients for lean weight in each wholesale cut relative to the total lean weight in carcass right side are presented in table 2. According to the three allometric models used, the results revealed that lean from brisket and flank cuts were considered to have a positive growth impetus, whereas lean from wholesale shoulder and rump cuts had a negative growth impetus. The growth impetus for lean in the other cuts in the present study were isometric. Fortin et al. (1980) showed that the proportion of muscle relative to total muscle in bovine carcass decreased in the thoracic and pelvic limbs and increased in the trunk. In this study, leans from the thoracic to those in shoulder and brisket cuts and leans from the loin, flank, rib and plate cuts to those in trunk. Therefore, the inclusion of shoulder and rump cuts as parts of the thoracic and pelvic limbs, respectively, probably explained their calculated low growth coefficients observed for the muscles in thoracic and pelvic limbs.

Growth coefficients for lean weights in all studied wholesale cuts varied ($p < .01$), except for rump ($p < .05$), with the increases in total lean weight in carcass side (table 2). However, growth coefficients increased with increased weight of lean in carcass side ($c > 0$) for leans from shoulder, rib, flank and leg cuts was faster than the rate of lean deposition in lighter weight carcasses.

TABLE 2. ALLOMETRIC GROWTH COEFFICIENTS (β)[a] THAT RELATE LEAN WEIGHT IN EACH CUT (Y) TO THE TOTAL LEAN WEIGHT OF CARCASS RIGHT SIDE (X) IN NAJDI MALE CAMELS (N = 18)

Wholesale cut	Model 1			Model 2			Model 3		
	β	SE	R^2	β	c	R^2	β	d	R^2
Neck	1.0	.07	.95	1.0	−.009**	.95	1.0	.003**	.95
Shoulder	.7	.09	.83	.7	.008**	.84	.8	−.011**	.84
Brisket	1.6	.14	.92	1.5	−.005**	.92	1.5	.002**	.92
Rib	1.0	.16	.77	1.0	.012**	.78	1.1	−.013**	.78
Plate	1.0	.08	.92	.9	−.017**	.94	.9	−.018**	.94
Loin	1.0	.11	.89	1.0	−.013**	.90	1.1	−.029**	.91
Rump	.6	.16	.54	.5	−.012*	.58	.4	.010**	.59
Flank	1.3	.15	.87	1.3	.010**	.87	1.3	.009**	.87
Leg	1.0	.04	.98	1.0	.005**	.98	1.0	.010**	.98

[a]Derived by the allometric equation in which the growth coefficient is a constant (model 1; $Y = \alpha X^{\beta}$), a linear function of total lean weight (model 2; $Y = \alpha X^{b} e^{cX}$; $\beta = b + cX$) or a linear function of slaughter age (A) (model 3; $Y = \alpha X^{b} e^{cX+dA}$; $\beta = b + cX + dA$).

* $p < .05$; ** $p < .01$

On the other hand, growth coefficients decreased with increased total lean weight in carcass side ($c < 0$) for leans from neck, brisket, plate, loin and rump cuts indicating that, at lighter weights, more lean was apparently deposited in these cuts than those carcasses of heavier weight. Thus, the concept that allometric growth coefficients for lean are constant throughout the growth was not supported by our data. Instead, lean growth in Najdi male camels was characterized by changes in the relative growth rates of wholesale cuts. Similar results were obtained in a study of swine by Evans and Kempster (1979) and in rams by Fourie (1962) and Notter et al. (1983). Furthermore, growth coefficients for lean weights in the studied cuts varied ($p < .01$) with age independent of weight of lean in carcass side (table 2). However, a significant age effect in model 3 would indicate real age effects and the sign of the age coefficient (d) should indicate the direction of the true relationship. At a given weight of total lean in carcass side, older Najdi male camels had larger coefficients ($d > 0$) for leans in neck, brisket, rump, flank and leg cuts, but had smaller coefficients ($d < 0$) for leans in shoulder, rib, plate and loin cuts. Thus, the yield of lean in rump, flank and leg cuts was maximized at heavier weights by older camels, while lean weight in plate and loin cuts in relation to the total lean weight in carcass side was minimized by heavier and older camels.

Generally, the growth coefficients for lean in thoracic limb (shoulder and brisket) and pelvic limb (leg and rump) described a dorsoventral rise in the growth impetus, with coefficients for the thoracic limb correspondingly higher than for the pelvic limb, probably reflecting their increased role for support as the weight of the camel shifts forward with age. Berg and Butterfield (1976) noted that smaller species tended to differ in muscle weight distribution from larger species, differences which may be related to relative demands on weight support muscles. Wilson (1984) stated that the heavy forequarter of the camel body has an important role in supporting the heavy weight of the head and neck. The wholesale cuts in the trunk and neck regions have an isometric growth impetus except for the flank cut which it has a relatively higher coefficients. Butterfield (1964) showed that the abdominal muscles were later developing than the muscles surrounding the spinal column. Also, growth of the abdominal muscles are related more to the size and weight of the contents of the abdominal cavity than to the growth of the total muscle in Merino sheep (Lohse et al., 1971). Berg et al. (1978) described the allometric growth patterns of muscles obtained from bulls. They observed several growth impetus waves that were centripetally on the limbs, caudocephalically on the whole of the body and dorsoventrally on the trunk. Generally, from what has been said so far, it is obviously difficult to compare in a detailed way the camel results with those obtained using various commercial jointing techniques in cattle and sheep carcasses.

According to the models used the allometric coefficients of lean weights in the wholesale cuts present a continuous rate of change up to 26 months of post-natal life. These changes may indicate the sense and magnitude in variations of relative growth rates but are less easy to interpret since each cut represent the combined effect of various individual muscles growing at different rates. The weights of muscle groups in the thoracic limb and pelvic limb suggested a dorsoventral rise in the growth impetus, with coefficients for the thoracic limb higher than for the pelvic limb. This reflects the concept of functional units proposed by Fowler (1968).

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