A STANDARD METHOD FOR JOINTING CAMEL CARCASSES WITH REFERENCE TO THE EFFECT OF SLAUGHTER AGE ON CARCASS CHARACTERISTICS IN NAJDI CAMELS. 3. PARTITION AND DISTRIBUTION OF CARCASS FAT

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Summary

The influence of age on the relative growth patterns of subcutaneous, intermuscular, intramuscular, perirenal, channel and hump fat in relation to the total fat weight in carcass sides of 18 Najdi male camels averaging 8, 16 and 26 months of age has been investigated. The total fat weight in a carcass side increased ($p < .01$) from 17.3% to 27.1% as the camel age increased from 8 to 26 months. However, at all ages studied, intermuscular fat weight was the largest fat depot, followed, in order, by subcutaneous and intramuscular fat. The change in weight of the intramuscular, intermuscular and subcutaneous fat between 8 and 26 months of age was greater, reaching 6.7, 4.3 and 4 times respectively, than the hump, channel and perirenal fat weight which increased by 3.6, 2.5 and 2.3 times, respectively. The allometric growth coefficient (β) for intramuscular fat in relation to the total carcass fat weight was the highest, followed, in order, by intermuscular, subcutaneous, hump, channel and perirenal fat.

(**Key Words**: Camel Carcass, Fat Depots, Fat Development, Slaughter Age)

Introduction

As meat animals grow, the partition of total carcass fat among the individual fat depots change but not uniformly from cut to cut (Johnson et al., 1972; Berg et al., 1978; Kempster, 1981). Kempster et al. (1976) and Taylor (1985) pointed to the fact that species and breed of animals differ considerably in the distribution and composition of different fat depots at equal fatness. Therefore, utilizing data from different experiments to characterize growth patterns of fat depots would be of limited value because the patterns of different species and breeds could have been affected by differences in the utilization of nutrients, environment and measurement (Leat and Cox, 1980; Talamantes et al., 1986). In approaching these problems, it is clear that a detailed knowledge of the evolution of adipose tissue within each species under a certain condition is required.

Although camel meat was the third rated meat of choice among the Saudi Arabian citizens in Riyadh Metropolitan area, 1986-1987 (Abouheif et al., 1989), studies determining the carcass characteristics of indigenous camels, including the Najdi camel which is the predominant breed in the Riyadh region, are limited. The primary objective of this study was to examine the differential growth and the relative proportions of various carcass fat depots of Najdi male camels slaughtered at 8, 16 and 26 months of age.

Materials and Methods

Eighteen Najdi male camels were selected from the Najdi camel productivity project (AR 6-60) at King Saud University, Riyadh, Saudi Arabia, and assigned to three slaughter age groups (8, 16 and 26 months) of six animals each representing the favorable range of weights and ages in the local Saudi market. The camel calves were creep fed on alfalfa hay and commercially formulated dairy calf starter concentrate (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

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and consisted of 40% alfalfa hay, 15% wheat straw and 45% commercial concentrate. Water, salt and mineral mixture were provided.

The body weight of each camel was recorded to the nearest 1 kg after an 18 hr period without feed. Immediately after weighing, camels were slaughtered at a commercial slaughterhouse. Hot carcass weight 30 to 45 min after slaughter was measured to the nearest .5 kg. Thereafter, carcasses were allowed to chill for 36 hr at 10℃ before splitting down the carcasses into right and left sides. The chilled sides were returned to the University Meat Laboratory for processing. The perirenal (kidney fat), channel (pelvic fat) and hump fat from the right side of each carcass were removed by careful trimming from the underlying tissues and their weights recorded to the nearest 5 g. Right sides of the carcasses were then fabricated into nine standard wholesale cuts following the procedure previously described by Abouheif et al. (1990). Each cut was physically trimmed of subcutaneous fat which defined as fat superficial to the plane of muscles. Furthermore, muscles from each cut were removed and the fat removed from their surfaces and between muscles and bones was recorded as intermuscular fat. The muscles from each cut were then grounded through a .3 cm plate, mixed and regrounded, and a representative sample was taken for chemical fat determination. Ether-extract in each cut (intramuscular fat) was measured in duplicate using the procedure outlined by AOAC (1980). For this study, total fat weight in a carcass side was the sum of subcutaneous, intermuscular and intramuscular fat weights from all wholesale cuts plus the weights of perirenal, channel and hump fat. It should be mentioned that perirenal, channel, hump, subcutaneous and intermuscular fat were measured as dissectible fat depots, whereas intramuscular fat was measured as ether-extract (the only way it it can be assessed). This means that intramuscular fat was measured on a different basis from the other fat depots.

The relationship of the weight of each fat depot (Y) to cold carcass side weight or total fat weight in each carcass side (X) was examined using the allometric formula, $Y = \alpha X^{\beta}$. The growth coefficients (β) were used to classify the fat depots into three growth impetus groups: positive impetus ($\beta > 1.0$), isometric impetus ($\beta = 1.0$) and negative impetus ($\beta < 1.0$); the t-test was used to examine if β is different from 1.0. All statistical analyses used the statistical analysis system (SAS, 1986).

Results and Discussion

Total fat weight in carcass side and its components: namely perirenal, channel, hump, subcutaneous, intermuscular and intramuscular fat, increased ($p < .01$) as the camel age increased from 8 to 26 months (table 1). The percentage of total fat weight in the carcass side increased from 17.3 at 8 months of age to reach an average value of 27.1 by 26 months. Although the percentage of total fat weight in the camel carcass increased rapidly during this stage of growth, it is important to note that these percentage values were substantially lower than those values reported for bovine carcasses by Cianzio et al. (1985) and Talamantes et al. (1986), and for ovine carcasses by Hammond et al. (1971) and Abouheif et al. (1988). However, it is assumed that these differences were probably due largely to species differences and feeding regimen. Taylor (1985) stated that fat deposition in animals is particularly influenced by species differences and the stage of maturation imposed on the animals; fat occupies a smaller proportion of the carcass at immature stages and increases as animals become more mature. Thus at similar age, carcasses from late maturing species, likely camels, possess a lower percentage of total fat than those from relatively earlier maturing species, namely sheep and cattle.

The change in weight of the intramuscular, intermuscular and subcutaneous fat between 8 and 26 months of age was greater, reaching 6.7, 4.3 and 4 times respectively, than the hump, channel and perirenal fat weight which increasing by 3.6, 2.5 and 2.3 times, respectively. Generally, at all studied ages, intermuscular fat weight was the largest fat depot, followed, in order, by subcutaneous and intramuscular fat. This is in agreement with reports from Fortin et al. (1981), Jones (1983) and Cianzio et al. (1985) in studies with several breeds of cattle. On the other hand, in sheep there were approximately equal amounts of intermuscular and subcutaneous fat (Field et al., 1985; Thompson et al., 1988), whereas in pigs subcutaneous fat far exceeded intrermuscular fat in weight (Leat and Cox, 1980).

The proportion of subcutaneous to intermuscular fat in camel carcasses varied from .75 to .81 over the range of the studied ages. Several reports have documented important species differences in the manner in which animal partition carcass fat. In this regard, the ratio of subcutaneous to intermuscular fat varied from .4 to .6 in cattle (Fortin et al., 1981; Cianzio et al., 1982 and 1985) and reached a value as high as 2.4 in pigs (Leat and Cox, 1980), which possibly reflects the intensity of selection for meat qualities. Berg and Walters (1983) proposed that genetic tendencies toward early fattening result in an increased proportion of subcutaneous relative to intermuscular fat, while delayed fattening produces the opposite effect. Existing results concerning the proportion of subcutaneous to intermuscular fat in Najdi male camels indicated that they tended to occupy an intermediate position relative to cattle and sheep. Therefore, the increased contribution of subcutaneous to intermuscular fat in later maturing camel carcasses than in cattle is intriguing. The discrepancy may be explained by true species differences in fat distribution.

Means for subcutaneous, intermuscular and intramuscular fat weights in each wholesale cut

TABLE 1. THE DISTRIBUTION OF VARIOUS FAT DEPOT WEIGHTS IN CARCASS SIDE OF NAJDI MALE CAMELS OF THREE AGES

Character	Age (months)			
	8	16	26	SE
No. of camels	6	6	6	
Live weight (kg)	171.2^{c}	295.4^{b}	450.9^{a}	14.20
Carcass side (kg)	52.6^{c}	88.4^{b}	136.7^{a}	12.10
Perirenal fat (kg)	.3^{b}	.6^{a}	.7^{a}	.01
Channel fat (kg)	.2^{b}	.2^{b}	.5^{a}	.01
Hump fat (kg)	2.4^{c}	5.6^{b}	8.6^{a}	.42
Subcutaneous fat (kg)	2.5^{c}	5.3^{b}	10.0^{a}	.18
Intermuscular fat (kg)	3.1^{c}	6.4^{b}	13.3^{a}	.72
Intramuscular fat (kg)	.6^{c}	1.5^{b}	4.0^{a}	.02
Total fat in carcass side	9.1^{c}	19.6^{b}	37.1^{a}	2.30

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

TABLE 2. THE DISTRIBUTION OF VARIOUS FAT DEPOT WEIGHTS IN WHOLESALE CUTS OF NAJDI MALE CAMELS OF THREE AGES

Wholesale cut	Fat depot											
	Subcutaneous				Intermuscular				Intramuscular			
	8	16	26	SE	8	16	26	SE	8	16	26	SE
Neck (kg)	.07	.07	.09	.03	.03^{b}	.08^{b}	.23^{a}	.11	.03^{c}	.10^{b}	.17^{a}	.02
Shoulder (kg)	.11^{c}	.51^{b}	.87^{a}	.18	.81^{c}	1.12^{b}	1.67^{a}	.25	.13^{c}	.27^{b}	.62^{a}	.07
Brisket (kg)	.28^{b}	.52^{a}	.52^{a}	.10	.22^{c}	.32^{b}	1.08^{a}	.17	.08^{c}	.17^{b}	.48^{a}	.12
Rib (kg)	.54^{c}	1.22^{b}	2.80^{a}	.42	.32^{c}	1.09^{b}	2.30^{a}	.50	.09^{c}	.29^{b}	.65^{a}	.10
Loin (kg)	.60^{c}	.96^{b}	1.89^{a}	.41	.31^{c}	.59^{b}	1.96^{a}	.68	.07^{b}	.14^{b}	.34^{a}	.02
Rump (kg)	.10^{c}	.24^{b}	.34^{a}	.03	.21^{c}	.39^{b}	.57^{a}	.07	.05^{b}	.08^{b}	.22^{a}	.05
Plate (kg)	.27^{c}	.79^{b}	1.68^{a}	.22	.73^{c}	1.99^{b}	3.55^{a}	.50	.07^{c}	.32^{b}	.58^{a}	.01
Flank (kg)	.16^{c}	.36^{b}	.66^{a}	.17	.16^{c}	.35^{b}	1.38^{a}	.41	.01^{b}	.05^{b}	.14^{a}	.01
Leg (kg)	.39^{c}	.66^{b}	1.13^{a}	.17	.31^{c}	.49^{b}	.63^{a}	.10	.05^{b}	.07^{b}	.75^{a}	.01

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

by the three slaughtering ages are shown in table 2. Except for subcutaneous *fat* in neck *cut*, various depots of fat in each cut tended to increase in weight ($p < .01$) as the age of Najdi male camel advanced from 8 to 26 months. Generally, intermuscular fat was the largest fat depot in shoulder, brisket, rump, plate and flank cuts, followed, in order, by subcutaneous and intramuscular fat, whereas in the rib, loin and leg cuts subcutaneous fat exceeded intermuscular and intramuscular fat in weight. In the neck cut, there were approximately equal amounts of intermuscular and intramuscular fat which surpassed subcutaneous fat in quantity. The distribution percentages of different fat depot weights within each wholesale cut in relation to the corresponding bone-in wholesale cut weight are shown in figure 1. As the age increased from 8 to 26 months, there were an increase ($p < .01$) in subcutaneous fat percent in shoulder, rib, loin and plate cuts. Similar increases were also observed for intermuscular fat percent in rib, loin, plate and flank cuts, and for intramuscular fat percent in plate, flank and leg cuts. Regardless the type of fat depot, the results showed that the rib, loin, plate and flank cuts were the fattiest cuts among the studied wholesale cuts of Najdi male camels, whereas neck, brisket and leg cuts were the leanest cuts.

The rates of fat deposition in the perirenal, channel, hump, subcutaneous, intermuscular and intramuscular depots in relation to the weight of carcass side or to the weight of total fat in the carcass side are presented in table 3. The growth coefficient for total fat weight in carcass side was higher than unity ($p < .01$), indicating that as carcass side weight increased, proportion of fat in carcass side increased at a faster rate. These results are consistent with Berg and Butterfield (1968), Mukhoty and Berg (1971) and Talamantes et al. (1986), who reported a growth coefficient greater than unity for total fat in carcass. Expressing the growth coefficients for the various fat depots relative to the weight of total fat in carcass side rather than to the weight of carcass side did not change the differential trends among the fat depots. Generally, a differential fat accumulation among depots was ob-

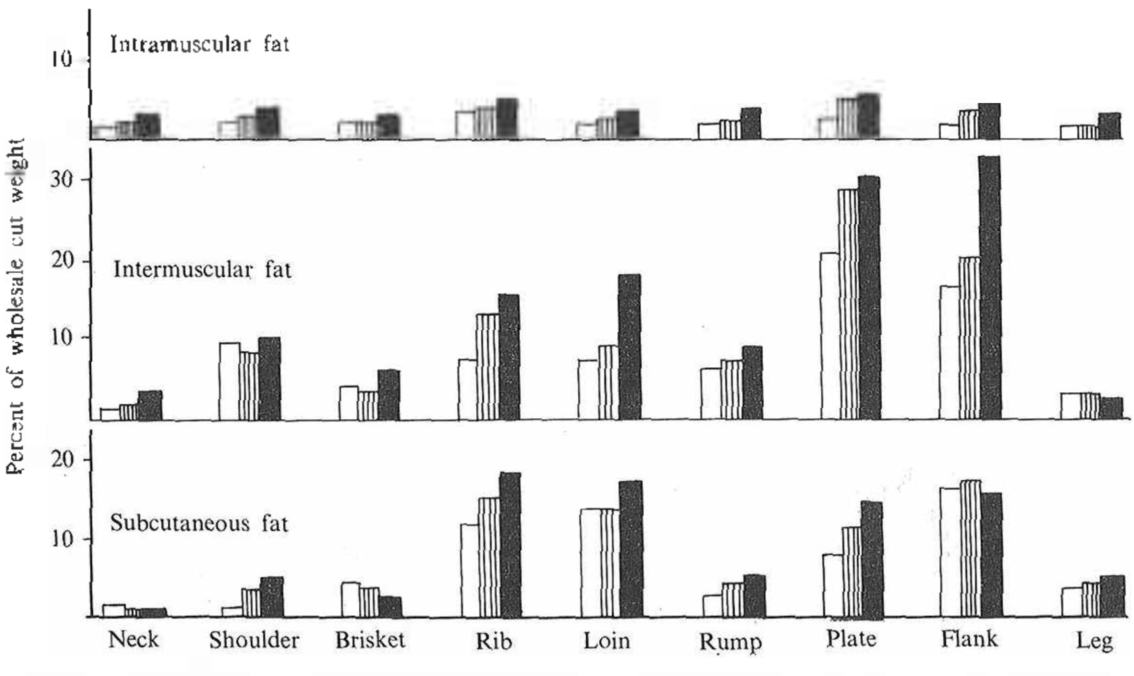

Figure 1. The distribution percentages of various fat depot weights within each wholesale cut in relation to the corresponding wholesale cut weight from Najdi male camels of three ages: ☐ 8 months of age, ▥ 16 months of age and ■ 26 months of age.

TABLE 3. GROWTH COEFFICIENTS (β) FOR VARIOUS FAT DEPOTS RELATIVE TO CARCASS SIDE WEIGHT OR TOTAL FAT WEIGHT IN CARCASS SIDE OF NAJDI MALE CAMELS (n = 18)

Character	Carcass side weight			Fat weight in carcass side		
	β	t^a	R^2	β	t	R^2
Fat in carcass side	1.51	>1	.96			
Perirenal fat	.96	= 1	.63	.63	<1	.64
Channel fat	1.35	>1	.70	.81	<1	.73
Hump fat	1.42	>1	.74	.99	= 1	.85
Subcutaneous fat	1.47	>1	.97	.96	= 1	.97
Intermuscular fat	1.55	>1	.92	1.01	= 1	.93
Intramuscular fat	1.78	>1	.92	1.28	>1	.90

[a] t-test to show if β is different from 1 ($p < .01$).

served, with the lowest growth coefficient for perirenal fat, followed, in ascending order, by channel, hump, subcutaneous, intermuscular and intramuscular fat, indicating that perirenal fat is the earliest developing fat depot in the Najdi male camel. These results are in accordance with those reported by Hammond et al. (1971) who stated that fat tissue tends to be deposited first in the perirenal and adjacent internal depots. On the other hand, Cianzio et al. (1982) and Tatum et al. (1986) concluded that kidney fat in cattle should not be considered as earlier developing tissue among fat depots; it increased at the same rate as total fat in the body. Also, Kempster (1981) found that kidney knob and channel fat tended to grow at an intermediate rate between subcutaneous and intermuscular fat in cattle and sheep. The discrepancies may be explained by differences in animals used. The contribution of each fat depot to total fat weight in carcass side suggested that intramuscular fat was the latest developing depot in Najdi male camel. Intermuscular and subcutaneous fat increased at the same rate as total fat in carcass side. Therefore, they should not be considered as earlier developing tissues among fat depots. These results are in general agreement with those reported by Hammond et al. (1971). Literature reports for cattle are discordant; Kempster et al. (1976), Cianzio et al. (1982) and Tatum et al. (1986) found that the rate of accumulation of intermuscular fat decreased as total carcass fat increased, whereas rate of accumulation for subcutaneous fat increased as total carcass fat increased. Fat deposition within the body cavity is of little value, whereas deposits of fat in the intramuscular depot has a high value because of its supposed contribution to increased marbling. Accordingly, it can be concluded that the increasing of camel carcass in weight could not only increase the quantity of meat production, but may also improves the quality of the meat.

The coefficients for growth of fat in subcutaneous, intermuscular and intramuscular depots relative to the carcass side weigth or to the total fat weight in carcass side are presented in table 4 for each wholesale cut. Expressing growth coefficients relative to weight of total fat in carcass side rather than to carcass side weight reduced the coefficient values for all fat depots in each cut. Similar results were found by Jones (1983) and Talamantes et al. (1986). Subcutaneous fat growth coefficient was generally equal to or higher than unity ($p < .01$) in each wholesale cut except for neck and brisket cuts. The highest growth coefficients were found in shoulder and plate which indicated that these areas would be associated with the greatest deposition of subcutaneous fat during the camel growth. With the exception of wholesale shoulder, rump and leg cuts, the intermuscular fat growth coefficient in each cut was greater than unity ($p < .01$) with the highest values found in flank, rib and neck cuts. These results are in partial agreement with those obtained by Jones (1983) in Holstein cattle. Differential intermuscular fat growth among the various wholesale cuts was clearly evident, although no clear growth gradient along the carcass could be discerned. On the other hand, Berg and Butterfield (1976) found that growth impetus for

TABLE 4. GROWTH COEFFICIENTS (β) FOR FAT IN VARIOUS DEPOTS RELATIVE TO CARCASS SIDE WEIGHT OR TOTAL FAT WEIGHT IN CARCASS SIDE OF NAJDI MALE CAMELS ($n = 18$)

Wholesale	Carcass side weight						Fat weight in carcass side					
	Subcutaneous		Intermuscular		Intramuscular		Subcutaneous		Intermuscular		Intramuscular	
cut	β	t[a]	β	t	β	t	β	t	β	t	β	t
Neck	.21	<1	1.84	>1	2.09	>1	.10	<1	1.34	>1	1.36	>1
Shoulder	2.09	>1	.83	<1	1.67	>1	1.40	>1	.55	<1	1.23	>1
Brisket	.74	<1	1.78	>1	1.72	>1	.50	<1	1.21	>1	1.30	>1
Rib	1.87	>1	1.98	>1	2.17	>1	1.22	>1	1.34	>1	1.36	>1
Loin	1.10	= 1	1.80	>1	1.88	>1	.89	= 1	1.28	>1	1.21	>1
Rump	1.18	= 1	.88	<1	1.31	>1	1.03	= 1	.51	<1	.89	= 1
Plate	1.95	>1	1.67	>1	2.12	>1	1.31	>1	1.14	= 1	1.31	>1
Flank	1.52	>1	2.31	>1	3.06	>1	.94	= 1	1.53	>1	1.91	>1
Leg	1.17	= 1	.78	<1	3.10	>1	.91	= 1	.56	<1	2.03	>1

[a] t-test to show if β is different from 1 ($p < .01$).

cattle intermuscular fat development was greater in the forequarter than in the hindquarter. Intramuscular fat growth coefficient was generally larger than those for subcutaneous or intermuscular fat in each of the cuts. The growth coefficient for the intramuscular fat in each cut was greater than unity ($p < .01$) with the highest values found in the leg and flank cuts.

In general, the rates of various fat depots deposition indicated a substantial differences in the developmental patterns of partitioning fat depots among the wholesale cuts. However, changes in the relative proportions of fat depots occur during growth and have important effects on fat quantity and quality. Young fat tissue contains a high proportion of water and connective tissue and a low proportion of ether extract contained in small cells. As the animal gets older, cell size increases; consequently the proportion of ether-extract increases and those of water and connective tissue decrease (Leat and Cox, 1980). Therefore, it is likely that if the fat content of perirenal, channel, hump, subcutaneous and intermuscular depots was assessed as ether-extract instead of dissectible fat, the growth coefficient values would be increased and the relative ranking may by changed.

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