The relationship between liveweight and carcass weight in steers of different maturity type fed high and low energy diets

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Introduction

The relationship between liveweight and carcass weight (dressing percentage) in beef cattle is known to be influenced by many factors. Preston and Willis (1974) considered that dressing percentage was primarily influenced by gutfill, animal fatness and muscle thickness. However, other factors such as whether kidney and pelvic fat are removed prior to recording warm carcass weight will also influence dressing percentage. Kauffmann et al. (1976) considered that muscling or muscle thickness became the most important trait influencing dressing percentage when gutfill was held constant. The same authors also observed that heavily muscled cattle had higher dressing percentages because their body cavities were proportionately smaller than poorer muscled cattle. No information however was presented on the proportional contribution of the organs to empty body weight for cattle exhibiting different degrees of muscling.

Large breed evaluation trials have produced some conflicting results concerning the dressed yield of carcasses. For example Koch et al (1976) showed no significant differences in dressing percentage for animals varying in mature size when the data was adjusted to constant age, constant weight or a constant 5% fat in the longissimus muscle. In contrast Kempster et al. (1982) reported that large crossbreds (Charolais, Simmental) had dressing percentages 2% higher than small cross breds (Angus, Hereford) when evaluated to a constant proportion of subcutaneous fat. It should be noted that it is not possible to explain these conflicting results without accounting for the weight of the gut contents and offal components. Relatively few studies have examined the distribution of the offal components in beef cattle despite some evidence that they very due to genotype and diet (Leche, 1973; Murray et al, 1977).

The objective of the present study was to determine the relationship between liveweight and carcass weight in steers of different maturity type fed concentrate and forage diets. Offal component variation was also investigated to determine its effect on dressing percentage.

Materials and Methods

Data for this study was collected from three trials which were conducted from 1980-1983. Data were combined since no significant differences were found among replicates and the experimental procedure was similar for all trials.

One hundred and ninety feeder steers comprised of 64 small (S) rotational crossbreds, 66 (L) large rotational crossbreds and 60 Holsteins (H) were provided with either a concentrate or forage diet ad-libitum. The small rotational crossbreds were mainly sired by Hereford bulls with lesser numbers sired by Angus, Shorthorn, Pinzgauer and Tarentaise bulls with dams being Hereford or small rotational crossbred cows. The large crossbreds were mainly sired by Charolais and Simmental bulls with lesser numbers sired by Maine-Anjou and Blonde D'Aquitaine bulls bred to large rotational crossbred cows. The Holsteins were purchased in groups from commercial dairy farms.

The steers were all castrated surgically and dehorned at weaning and given a single implant in the left ear of Synovex S. The steers were then allocated to pens holding four cattle at random within maturity type and fed a concentrate or forage diet ad-libitum. The concentrate diet consisted of approximately 30% corn silage and 70% high moisture corn on a dry matter basis. The forage diet was a 50:50 mixture of corn silage and alfalfa haylage. In total there were 94 cattle (32(S), 33(L), and 29(H)) fed the concentrate diet and 96 cattle (32(S), 33(L) and 31(H)) cattle fed the forage diet.

Steers were slaughtered at random over a wide range of carcass fat thicknesses (0-15 mm) determined by a Scanogram (Model 721). Feed was withheld from steers for 36 h and water 16 h prior to slaughter. Offal components were weighed after slaughter and the digestive tracts were emptied of digesta and weighed as described by Jones (1981). Warm carcass weight excluded the weight of the kidney and pelvic fat. Empty body weight was considered as the animal liveweight less the weight of the digesta, blood, tail and reproductive tract. One side of each carcass was physically separated into fat, lean and bone as described by Jones (1983), so that empty body weight could be adjusted to a constant proportion of external or subcutaneous fat.

Data were statistically analyzed using a two way analysis of variance to examine the effects of genotype, diet and genotype x diet interaction. Analysis of covariance was also employed to adjust the data to a constant degree of subcutaneous fatness. Empty body weight was adjusted to a constant proportion of subcutaneous fat (62g/kg empty body weight) which approximates 6 mm of fat thickness at the 11/12th rib, so that components of empty body weight could be compared among maturity types and between diets in the absence of gutfill and at a similar level of external fatness. Growth coefficients for all offal components were obtained by linear regression analyses using the allometric equation.

Results

The overall means for liveweight at slaughter and empty body weight parameters for the 3 maturity types of steers are shown in Table 1. S and H steers had lower weights at slaughter than L steers, but S steers had the greatest percentage of dissected subcutaneous carcass fat. Carcass from L steers were heavier (P<0.001) than those from S and H steers. L steers had the highest dressing percentage (P<0.01), H steers the lowest (P<0.01) with S steers having intermediate values (Table 1). Except for the mesenteric fat depot and small and large intestine weights, all of the empty body components differed significantly among the three maturity types of steers.

Concentrate and forage fed steers had similar average weights at slaughter (Table 1). However, concentrate fed steers produced heavier carcasses (P<0.05) which resulted in a greater dressing percentage (P<0.05) than forage fed steers. Concentrate fed steers had a greater proportion of carcass subcutaneous fat (P<0.05) than forage fed steers. Diet also influenced the weight of the body organs (spleen, heart, liver, lungs), the visceral fat depots (caul, mesenteric, kidney and pelvic fats) and components of the digestive tract (omasum, small intestine).

The carcass comprised a greater proportion (P<0.01) of empty body weight in L steers than S steers or H steers (Table 2). H steers had the lowest proportion of hide relative to empty body weight (P<0.01). However, H steers had empty bodies with higher proportions of body organs (spleen, heart, liver, lungs), visceral fat depots and components of the digestive tract than the beef breeds, which aids in explaining their lower yield of dressed out carcass. There were also important differences found in the proportions of empty body components between L and S steers (Table 2). L steers had lower proportions of head, hide, body organs (liver, lungs, kidneys) and components of the digestive tract (rumen, omasum, abomasum, small and large intestine) than S steers.

In the absence of gutfill and at the same level of external fatness, diet had no effect on carcass weight expressed as a proportion of empty body weight (Table 2). Steers fed forage diets however had proportionately more head, hide, distal front feet, omasum and small intestine than those fed concentrate diets (P<0.01). Caul and mesenteric fat depots, liver and lungs however formed a greater proportion of empty body weight for steers fed concentrate than those fed forage diets (P<0.01).

Allometric growth coefficients relating empty body component mass to empty body weight were different (P<0.01) among maturity types except for carcass weight, caul fat, reticulo-rumen, omasum and the large intestine (Table 3). Growth coefficients for the body organs, digestive tract, head and feet were also less than one indicating that these parameters became a decreasing proportion of the empty body as weight increased. Carcass weight had a growth coefficient not different to unity, whereas the same values for the visceral fat depots were greater than one. Allometric growth coefficients for empty body components in steers fed concentrates or forages were generally similar (Table 3). However, steers fed forage diets had greater growth coefficients for the head and hide than concentrate fed steers, but had a lower coefficient for the mesenteric fat depot.

Discussion

Examination of the components of the empty body on an average or mean weight basis showed that the L steers had the greatest liveweight at slaughter and produced heavier weights of carcass giving higher values for dressing percent than those found for S or H steers. However, L steers did not consistently have the greatest weights of body organs, visceral fat depots or components of the digestive tract even though they had the heaviest empty body weight. This observation would suggest that maturity type had an influence on the relative contribution of the different body parts to empty body weight. Concentrate fed steers produced heavier warm carcass weights than forage fed steers when slaughtered at a similar weight. However, concentrate fed steers tended to produce higher organ weights and visceral fat weights than forage fed steers again indicating that diet may influence the components of the empty body. Other reports in the literature have shown that forage feeding compared to concentrate feeding depresses the dressed yield of carcass weight (Prior et al. 1977; Bowling et al. 1978), but few authors have attempted to explain whether this is due to a greater weight of gut contents in forage fed steers or a dietary modification in weights of the empty body components.

When compared on an empty body weight basis at the same proportion of subcutaneous fat, L steers had the highest proportion of warm carcass weight and H steers the lowest. This difference amounted to 35 g of carcass/kg of empty body weight. On an average empty body weight of 400 kg, this would mean 14 kg more warm carcass for the L steers compared to the H steers. The same comparison for L and S steers showed L steers to have 22 g more carcass/kg of empty bodyweight giving 8.8 kg more warm carcass for an average empty body weight of 400 kg.

As the warm carcass was a higher proportion of empty body weight in L steers compared to S and H steers, it would be reasonable to expect some differences in the proportions of the other empty body components. H steers had the highest proportion of body organs (except kidneys), visceral fat depots and components of the digestive tract (except small intestine) while S steers had values that were generally intermediate to L and H steers. Thus it was concluded that H steers had significantly lower dressing percentages than beef steers because of proportionately heavier visceral organs, digestive tracts and visceral fat depots. There are other published reports which support the findings of the present study. Andersen et al. (1979) reported that dairy breeds had larger body organs (kidneys and lungs) than beef breeds. Callow (1961) and Truscott et al. (1976) found that dairy cattle had greater development of the visceral fat depots in comparison to the traditional beef breeds. The findings of the present study would also support the conclusions of Kauffman et al. (1976) who demonstrated that degree of muscling was negatively correlated with the size of the body cavity.

The findings of the present study may also be extended to published results on feed efficiency in beef and dairy breeds of cattle. Body organs have been shown to be more metabolically active than the carcass tissues (Baldwin et al, 1980). Other studies have shown the Holstein feeder cattle require more dietary energy for maintenance functions than those of traditional beef breeds (Garrett, 1971; Webster et al, 1977). Although no energy balance work was conducted in the present trial, it is possible that the higher maintenance requirements for Holstein cattle compared to the beef breeds may partly stem from a greater proportion of the empty body being comprised of visceral organs. In addition H steers were found to partition a greater proportion of fat into the visceral fat depots (caul, mesenteric and kidney) than beef steers at the same level of external fatness. Kempster (1981) reported similar findings and suggested that selection for high milk production in the Holstein breed had indirectly led to an increased partition of the internal fat depots to provide a more ready supply of energy during periods of high energy demand such as the onset of lactation. It can be speculated that both the higher proportions of body organs and visceral fat in Holstein steers may increase maintenance requirements compared to beef steers.

Diet had no significant effect on warm carcass weight expressed as a proportion of empty body weight. This result would suggest that the depressing effect of forage feeding on dressing percentage often reported in the literature (Prior et al, 1977; Bowling et al, 1978) is mainly caused by greater amounts of residual gutfill in forage fed compared to concentrate fed animals. However, diet did influence offal component distribution. Steers fed a forage diet had proportionately more head, hide, distal front feet, and omasum than those fed a concentrate diet. The reverse situation held for the visceral fat depots, liver and lungs and small intestine. Murray et al. (1977) reported similar results except that digestive tract components were a greater proportion of empty body weight in steers grown at 0.8 kg/day compared to steers grown at 0.4 kg/day. This discrepency can probably be explained in that Murray et al. (1977) used restricted feeding of the same diet to achieve different growth performance, whereas the present study employed a concentrate and forage diet. Supporting evidence for the results of the present study is also provided by Henrickson et al. (1965) who reported greater amounts of visceral fat in animals fed high energy diets compared to medium energy diets.

The allometric growth coefficients for empty body component mass relative to empty body weight were different among maturity types except for carcass weight, caul fat, reticulo-rumen, omasum and the large intestine. However, the overall results would indicate that the body organs, digestive tract, head, hide and feet became a decreasing proportion of empty body weight as empty body weight increased. The carcass increased in weight at a similar rate as the empty body while the visceral fat depots increased in size at a proportionately faster rate of growth than the empty body. As the growth coefficient for the carcass was not different to one, it would suggest that dressed yield of carcass (excluding kidney and pelvic fat) would not increase with increases in carcass fatness in the range of weights covered in this study. Kauffmann et al. (1976) reported similar findings and suggested that as cattle fatten the proportion of fat deposited in the non-carcass component (mesentary) might change proportionally to the carcass fat component.

In conclusion the present study has shown important differences in dressing percentage for steers of different maturity types caused by differneces in the distribution of offal components. Diet was found to have no influence on dressing percent when the effect of gutfill was removed. The growth coefficients for carcass weight in relation to empty body weight were close to unity indicating no change in dressing percentage with increased weight and fatness.

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Table 1. Liveweight, carcass weight and empty body parameters for steers of different maturity type fed concentrate or forage diets.

	Small Crossbreds	Large Crossbreds	Holstein	SE	Effect of maturity type	Concen- trates	Forage	SE	Effect of diet
Observations	64	66	60		**	94	96		
Liveweight kg	393a	457b	409a	22.5	**	428	413	18.4	NS
Warm carcass wt kg	229.3a	278.1b	231.4a	14.5	**	254.5	239.5	11.9	*
Dressing percent %	58.2a	60.7b	56.1c	0.4	**	59.2	57.6	0.3	**
Subcutaneous fat %	7.0a	5.8b	5.9b	0.3	**	6.5	5.9	0.2	*
Non carcass parts:									
Head kg	13.5a	15.0b	14.6ab	0.6	**	14.3	14.4	0.5	NS
Hide kg	35.0a	38.6b	29.9c	1.8	**	34.8	34.4	1.5	NS
Distal front feet kg	3.9a	5.0b	4.5c	0.2	**	4.4	4.5	0.2	NS
Distal hind feet kg	4.2a	5.3b	4.8c	0.2	**	4.8	4.8	0.2	NS
Organs:									
Spleen kg	0.7a	0.9b	0.9b	0.1	**	0.9	0.8	<0.1	*
Heart kg	1.4a	1.7b	1.6b	0.1	**	1.6	1.5	<0.1	**
Liver kg	4.4a	4.9b	5.1b	0.2	**	5.0	4.6	<0.2	**
Lungs & trachea kg	5.2a	5.9b	6.6c	0.3	**	6.2	5.6	<0.3	**
Kidneys kg	0.9a	0.9a	1.1b	0.1	**	1.0	0.9	<0.1	NS
Visceral fat depots:									
Caul kg	5.6a	6.3a	9.4b	1.0	**	8.2	5.9	0.8	**
Mesenteric kg	3.7	3.9	4.7	0.6	NS	4.7	3.5	0.5	**
Kidney & pelvic kg	4.5a	5.6ab	6.2b	0.8	**	5.9	5.1	0.6	*
Digestive tract:									
Reticulo-rumen kg	8.9a	9.6ab	10.2b	0.6	**	9.5	9.6	0.4	NS
Omasum kg	4.4a	4.4a	5.2b	0.4	**	4.3	5.0	0.3	**
Abomasum kg	2.2a	2.2a	2.6b	0.2	**	2.3	2.3	0.2	NS
Small intestine kg	6.5	6.3	6.2	0.5	NS	6.7	6.0	0.3	**
Large intestine kg	5.7	5.9	6.3	0.6	NS	6.0	5.8	0.4	NS

abc Means in the same row for maturity type are significantly different (P<0.01)

[illegible]

	Small Crossbreds	Large Crossbreds	Holstein	SE	Effect of maturity type	Concen- trates	Forage	SE	Effect of diet
Warm carcass wt	671a	693b	658c	2.5	**	674	673	2.0	NS
Non-carcass parts:									
Head	41a	37b	42a	0.5	**	39	41	0.4	**
Hide	103a	97b	85c	1.2	**	93	97	1.0	**
Distal front feet	12a	12a	13b	0.2	**	12	13	0.2	**
Distal hind feet	13a	13a	14b	0.2	**	13	13	0.1	NS
Organs:									
Spleen	2a	2a	3b	0.1	**	2	2	0.1	NS
Heart	4a	4a	5b	0.1	**	4	4	0.1	NS
Liver	13a	12b	15c	0.2	**	14	13	0.2	**
Lungs & trachea	16a	15b	19c	0.3	**	17	16	0.2	**
Kidneys	3a	2b	3a	0.1	**	3	3	0.1	NS
Visceral fat depots:									
Caul	15a	16a	26b	0.9	**	21	17	0.7	**
Mesenteric	10a	10a	13b	0.5	**	12	10	0.4	**
Kidney & pelvic	12a	14b	17c	0.7	**	15	14	0.5	NS
Digestive tract:									
Reticulo-rumen	26a	24b	29c	0.6	**	26	27	0.5	NS
Omasum	14a	11b	15a	0.5	**	12	15	0.4	**
Abomasum	7a	5b	8a	0.5	**	7	7	0.4	NS
Small intestine	20a	16b	18c	0.7	**	19	17	0.5	**
Large intestine	17a	15b	18a	0.7	**	17	16	0.5	NS

abc Means in the same row for maturity type are significantly different (P<0.01)

d Values are adjusted to 62g of subcutaneous fat per kg of empty body weight

[illegible]

	Small Crossbreds	Large Crossbreds	Holstein	SE	Effect of maturity type	Concen- trates	Forage	SE	Effect of diet
Warm carcass wt	1.07	1.05	1.08		NS	1.09	1.08	0.02	NS
Non carcass parts:									
Head	0.76a	0.64b	0.67b	0.05	**	0.63	0.72	0.04	**
Hide	0.93a	0.83b	0.86ab	0.06	*	0.84	0.99	0.06	**
Distal front feet	0.50a	0.73b	0.59ab	0.13	**	0.68	0.72	0.10	NS
Distal hind feet	0.61a	0.76b	0.64a	0.06	**	0.74	0.70	0.05	NS
Organs:									
Spleen	0.56a	0.80b	0.33c	0.13	**	0.52	0.58	0.10	NS
Heart	0.73a	0.92b	0.80ab	0.10	**	0.81	0.75	0.08	NS
Liver	0.64a	0.73b	0.62a	0.07	*	0.63	0.59	0.06	NS
Lungs	0.78a	0.94b	0.80a	0.08	**	0.79	0.69	0.07	NS
Kidneys	0.58a	0.38b	0.20c	0.10	**	0.22	0.31	0.09	NS
Visceral fat depots:									
Caul	1.89	2.14	2.15	0.24	NS	1.61	1.73	0.22	NS
Mesenteric	1.22a	1.67b	1.55b	0.22	*	1.55	0.93	0.18	**
Kidney & pelvic	1.55a	2.21b	2.08b	0.20	**	1.85	1.69	0.17	NS
Digestive tract:									
Reticulo-rumen	0.84	0.75	0.86	0.10	NS	0.71	0.83	0.08	NS
Omasum	0.40	0.30	0.35	0.17	NS	0.35	0.30	0.14	NS
Abomasum	0.08a	0.79b	0.46c	0.22	**	0.33	0.47	0.19	NS
Small intestine	0.44a	0.47a	0.29b	0.15	**	0.27	0.36	0.11	NS
Large intestine	0.41	0.49	0.35	0.22	NS	0.60	0.71	0.18	NS

abc Means in the same row for maturity type are significantly different (*P<0.05, **P<0.01)