# Callipyge gene effects on lamb growth, carcass traits, muscle weights and meat characteristics

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# Growth, carcass and cooked meat characteristics of lambs sired by Dorset rams heterozygous for the Callipyge gene and Suffolk and Texel rams

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**Abstract**

Dorset (D) rams heterozygous for the Callipyge gene were single—sire mated to non-carrier ewes to produce Callipyge heterozygous (CLPG, $n=49$) and normal (D, $n=33$) lambs. Suffolk (S) and Texel (T) rams were mated to similar ewes to produce non-carrier crossbred S ($n=55$) and T ($n=52$) lambs. Lambs were finished on a high-energy diet to a target live weight of 57 kg. Pre-slaughter weight was recorded for each lamb prior to its transfer and slaughter through a commercial facility. Hot carcass weight and kidney and pelvic fat (KPF) were recorded at slaughter. Chilled carcasses were measured then fabricated into trimmed retail cuts by plant personnel. Each cut was weighed, and two loin chops were collected from each carcass for later cooking. CLPG lambs had the highest dressing % (53.6 versus 49.8–50.6; $P<0.05$). At the same cold carcass weight, CLPG lambs had larger longissimus muscle areas (19.5 cm$^2$ versus 14.0–15.2 cm$^2$ for the rest; $P<0.05$), less KPF (0.9 kg versus 1.04–1.13 kg; $P<0.05$), less carcass fat ($P<0.05$ for all measures), shorter carcasses (60.7 cm versus 61.8–64.7 cm; $P<0.05$), and heavier trimmed sirloins, legs, and shoulders than any other group (a11 $P<0.05$). They were similar to S lambs in receiving the lowest mean USDA yield grade. CLPG carcasses had the highest proportion of carcass weight represented by trimmed cuts (70% versus 65.7–67.8% for the rest; $P<0.05$), the highest proportion of trimmed cuts (62.2% versus 59.7–60.6% for the rest; $P<0.05$) represented by the most valuable cuts (leg + loin + rack + sirloin), and the highest composite carcass value ($135.8 versus $125–129 for the rest; $P<0.05$). CLPG lambs also produced loin chops with the highest mean Warner–Bratzler shear values (5.4 kg versus 2.8–2.9 kg for the rest; $P<0.05$) and the highest % cooking loss (31% versus 29–29.6% for the rest; $P<0.05$).


*Keywords:* Lamb; Callipyge; Carcass; Meat

## 1. Introduction

American lamb producers are caught in a dilemma—processors are demanding heavier slaughter lambs in order to reduce processing overhead cost while consumers have reduced their consumption of fat from animal products as they have become more diet and health conscious (NRC, 1988). The American Sheep Industry Council has promoted a certified lean lamb classification and has been instrumental in implementation of a revised USDA lamb yield grading system to encourage production of leaner lamb carcasses. There

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is little evidence to date that producers of leaner lamb are receiving monetary rewards for their efforts.

The objective of this study was to examine growth, carcass and meat characteristics of lambs produced by terminal sires including rams heterozygous for the Callipyge gene. The study was designed to collect both carcass and economic value data through a commercial slaughter/fabrication system in order to examine both the physical and monetary aspects of carcasses of various genotypes.

## 2. Materials and methods

Lambs were produced by balanced designed mating of ewes of several breed types (Hampshire (H), Coopworth × Polypay (CP), Hampshire × Coopworth × Polypay (HCP) and Hampshire × Polypay (HP)) to Dorset rams heterozygous for the Callipyge (CLPG) gene, Texel rams, and Suffolk rams. The CLPG gene has been mapped to ovine chromosome 18 (Cocket et al., 1993, 1994) and its phenotype is characterized by a non-Mendelian inheritance pattern, referred to as polar overdominance (Cocket et al., 1996). The CLPG gene causes a rapid postnatal muscle hypertrophy and a reduction in adipose tissue deposition in sheep (Jackson et al., 1993; Snowder et al., 1994; Abdulkhaliq et al., 2002).

Ewes were run as a single flock from the end of mating through weaning of their lambs. Ewes were lambed through a barn where all lambs were identified at birth. All lambs were docked, and male lambs were castrated, by elastrator bands applied within 24 h of birth. Ewes and lambs grazed ryegrass/clover pasture without supplementation until weaning.

Lambs were designated by genotype/sire breed as Callipyge heterozygous (CLPG, $n = 49$), or non-Callipyge from Dorset (D, $n = 33$) or progeny of Texel (T, $n = 52$) or Suffolk (S, $n = 55$) sires. Genotype was assigned to each Dorset-sired lamb prior to weaning on the basis of visual and handling appraisal of muscularity. Three scorers independently assigned a muscling score on a 4-point scale of increasing muscularity. Scores of 1 and 2 were assessed as normal, 3 and 4 as Callipyge heterozygous. Following slaughter, these lambs were again assigned genotype based on carcass muscularity (esp. leg score and LMA) and leanness. Genotype assignment was completely consistent between the two scorings.

A total of 189 ewe and wether lambs of similar weaning weight and balanced for dam genotype were grown to a mean final live weight of 57 kg. Lambs were randomized within genotype and gender to concentrate versus pasture (grazing) treatments (TRT: 1 = concentrate, 2 = pasture). At weaning, concentrate lambs were penned indoors by genotype and gender and were started on the concentrate diet while the pasture lambs were grazed as a single group for a period prior to being finished indoors on the same concentrate diet.

Lambs were slaughtered in four groups of comparable size as they reached target slaughter weight of 57 kg. Lambs of all genotypes, types of birth and genders were uniformly represented in each slaughter group. Because the concentrate lambs grew faster, they reached target weights sooner and comprised all of the first and second slaughter groups. The third slaughter group was comprised of the remainder of the concentrate lambs and the faster growing of the pasture lambs while the fourth slaughter group contained pasture lambs only.

Live weights were recorded prior to trucking lambs to a commercial facility. At slaughter, hot carcass weight was recorded and pelvic fat (KPF) was removed and weighed.

After a 24-h chill period, yield grade and leg score were assigned by a plant USDA grader (USDA, 1992) and then carcass measurements were obtained by experienced university personnel. Carcass length was measured and cold carcasses were weighed and dissected between the 12th and the 13th ribs to measure longissimus muscle area (LMA) and several estimates of carcass fatness. Fat measurements included 12th rib fat thickness (FDL) measured over the center of the longissimus muscle, sacral fat thickness (FDS) measured at the middle of the fourth sacral vertebrae, lower rib fat thickness (FDR) measured at the point of the greatest fat thickness over lower rib, and body wall thickness (FDB) measured 5 cm ventral to the lateral edge of the longissimus muscle. Carcasses were then fabricated by plant personnel into trimmed, tray-ready retail cuts according to the following commercial procedure: Shoulders were removed from the carcass between the third and fourth ribs. The neckpiece was removed by cutting in a straight line extending from the back, and shoulders were separated by a cut through the vertebral column. The shanks and brisket were removed by a cut parallel to the backbone across the humerus slightly above the knuckle. Shanks were removed at the joint from the brisket. The wholesale rack was separated from the carcass between the 12th and the 13th ribs. The breast was separated from the wholesale rack 7.6 cm from LM. The rack was halved by a split down the spinal column. The loin was cut from the leg perpendicular to the backline between the last two lumbar vertebrae. The flank was separated from the loin 2.5 cm from the outer edge of the LM. The wholesale loin was halved down the vertebral column. The legs were also split down the vertebral

Table 1
Least-square means (±S.E.M.) for weight and carcass measures of normal (D) or Callipyge (CLPG) lambs sired by heterozygous Dorset rams and lambs sired by Texel (T) or Suffolk (S) rams

| Trait | Genotype | | | | S.E.M. | Gender | | S.E.M. |
|---|---|---|---|---|---|---|---|---|
| | D | CLPG | T | S | | Ewe | Wether | |
| Number | 33 | 49 | 52 | 55 | | 98 | 91 | |
| Pre-slaughter weight (kg) | 55.1 b | 54.6 b | 54.9 b | 59.5 a | ±0.47 | 55.5 a | 56.5 b | ±0.35 |
| Hot carcass weight (kg) | 28.7 b | 30.1 a | 28.6 b | 30.6 a | ±0.26 | 29.2 a | 29.8 b | ±0.20 |
| Cold carcass weight (kg) | 28.1 b | 29.5 a | 27.9 b | 29.5 a | ±0.26 | 28.6 a | 29.1 b | ±0.19 |
| Dressing (%) | 50.6 b | 53.6 a | 50.3 b | 49.8 b | ±0.29 | 51.0 | 51.1 | ±0.22 |
| LMA ($cm^2$)[a] | 14.0 c | 19.5 a | 15.2 b | 14.9 bc | ±0.30 | 16.0 | 16.1 | ±0.22 |
| Leg score | 11.8 c | 14.7 a | 13.1 b | 12.5 c | ±0.12 | 13.0 | 13.0 | ±0.09 |
| Leg length (cm) | 33.1 b | 32.5 c | 33.2 b | 33.9 a | ±0.19 | 33.1 | 33.3 | ±0.14 |
| Carcass length (cm) | 62.5 b | 60.7 c | 61.8 bc | 64.7 a | ±0.28 | 62.3 | 62.5 | ±0.19 |
| KPF (kg)[b] | 1.1 b | 0.9 a | 1.0 b | 1.1 b | ±0.04 | 1.1 a | 1.0 b | ±0.07 |

Means within a row and genotype or gender with different letters differ at $P < 0.05$.
[a] Longissimus muscle area.
[b] Kidney and pelvic fat.

column into two legs, and the shank portion was removed 3.8 cm below the joint. All cuts were trimmed to within 0.6 cm of external fat. Leg length and weight of each trimmed cut were recorded on the cutting table.

Two loin chops cut 2.5 cm thick were collected from each carcass, vacuum packed and stored at −18 °C awaiting collection of loin chops from all slaughter groups.

Chops were thawed overnight, trimmed to 0.3 cm external fat, weighed, and grilled to an internal temperature of 70 °C. Following cooking, loin chops were re-weighed to determine cooking weight loss, and two cores, each of 1.27 cm diameter and taken parallel to the muscle fibers, were collected from each chop. Cores were severed with a Warner–Bratzler shear apparatus (25 kg × 50 g dynamometer scale, G.R. Electric Mfg. CO., 1317 Collins Lane, Manhattan, KS) to measure shear force.

The cumulative weight of trimmed cuts from each carcass was divided by cold carcass weight to determine yield, weight of (leg + loin + rack + sirloin) was divided by total weight of trimmed cuts to determine % high-value cuts, and total carcass value was determined by an index of the respective weight of each trimmed cut multiplied by its current price/unit weight (being received by the commercial slaughter plant).

Data were analyzed using least-square procedures (Harvey, 1990), fitting models containing lamb genotype (D, CLPG, T, S), gender (ewe, wether), dam genotype (H, CP, HP, HCP), finishing treatment (concentrate, pasture) and/or slaughter group (1–4). Because finishing treatment and slaughter group were partially confounded, models were run with each included separately. Analyses of carcass measures and cumulative weight and value of trimmed cuts included cold carcass weight as a covariate. The Newman–Keuls pair-wise comparison procedure (Samuels and Witmer, 1999) was utilized to test the differences between the means of lamb genotypes for all traits.

## 3. Results and discussion

Least-square means are presented in Table 1 for some carcass measures adjusted to the mean cold carcass weight of 28.75 kg. Significant variation was observed among lamb genotypes for most traits, largely being due to the effect of Callipyge lambs. The CLPG lambs did not differ in pre-slaughter weight from normal lambs produced from D or T rams but were significantly ($P < 0.05$) lighter than lambs produced from S rams. Previous reports indicated little or no effect of the CLPG on lamb growth when compared to their normal siblings (Jackson et al., 1997; Freking et al., 1998; Abdulkhaliq et al., 2002). The means for hot carcass weight and cold carcass weight were heavier ($P < 0.05$) for the CLPG lambs when compared to T or D lambs but similar to S lambs. These results agree with Koomaraie et al. (1995) who reported heavier hot carcass weight for CLPG lambs. Also, Srinivasan (1997) and Jackson et al. (1997) reported similar results for both hot and cold carcass weights for CLPG lambs when compared to normal lambs.

Overall, mean dressing percentage was relatively low, probably a reflection of the time lag between recording pre-slaughter weight and weighing carcasses; however, CLPG lambs demonstrated higher dressing percent (cold carcass weight/pre-slaughter weight) than normal lambs

Table 2
Least-square means (±S.E.M.) for carcass fat measures adjusted for cold carcass weight and USDA yield grade of normal (D) or Callipyge (CLPG) lambs sired by heterozygous Dorset rams and lambs sired by Texel (T) or Suffolk (S) rams

| Trait | Genotype | | | | S.E.M. | Gender | | S.E.M. |
|---|---|---|---|---|---|---|---|---|
| | D | CLPG | T | S | | Ewe | Wether | |
| Number | 33 | 49 | 52 | 55 | | 98 | 91 | |
| Fat depth (cm) | | | | | | | | |
| Loin | 0.88 a | 0.53 b | 0.79 a | 0.58 b | ±0.04 | 0.72 | 0.67 | ±0.03 |
| Sacral | 2.20 a | 1.80 b | 1.89 b | 1.84 b | ±0.07 | 1.98 | 1.88 | ±0.05 |
| Lower rib | 2.24 a | 1.78 b | 2.00 ab | 1.84 b | ±0.07 | 2.05 a | 1.87 b | ±0.05 |
| Body wall | 3.00 a | 2.50 b | 2.60 b | 2.50 b | ±0.07 | 2.72 a | 2.58 b | ±0.05 |
| USDA yield grade | 3.60 a | 2.60 b | 3.20 ab | 2.70 b | ±0.28 | 3.20 a | 2.90 b | ±0.08 |

Means within a row and genotype or gender, with different letters differ at $P < 0.05$.

produced from D, T, and S rams (53.6% versus 50.2%; $P < 0.05$). Previous studies have also reported a higher dressing percent for CLPG lambs when compared to normal lambs (Abdulkhaliq et al., 2002; Jackson et al., 1997; Koomaraie et al., 1995; Snowder et al., 1994).

In general, CLPG carcasses were the most muscular (largest LMA, 19.5 $cm^2$ versus 14.0–15.2 $cm^2$ for the other three genotypes; $P < 0.05$), had the highest leg score (14.7 versus 13.1, 12.5 and 11.8 for T, S and D, respectively; $P < 0.05$) and had less internal fat (KPF; $P < 0.05$) than the other genotypes. They were shorter than the S and D carcasses ($P < 0.05$) but not significantly different from T carcasses ($P > 0.05$); also had the shortest legs ($P < 0.05$) compared to all other genotypes. Freking et al. (1998) previously reported that Callipyge carcasses were shorter ($P < 0.01$) than normal carcasses when compared at a constant carcass weight of 25.6 kg.

Among the other three genotypes, T lambs had the largest LMA and highest leg score, followed in order by S and D carcasses. S carcasses were both the longest of the four genotypes ($P < 0.05$) and produced the longest legs ($P < 0.05$).

Wethers were heavier than ewe lambs at slaughter ($P < 0.05$). Similar dressing % for the two genders resulted in wethers consequently recording heavier hot and cold carcass weights ($P < 0.05$). Ewe lambs had heavier KPF ($P < 0.05$) despite their lighter carcasses, a result in agreement with Srinivasan (1997).

Means for carcass fat measurements (adjusted for cold carcass weight) and USDA yield grades are shown in Table 2. All measurements were consistent, with CLPG lambs being the leanest followed in order by S and T lambs with normal D-sired lambs being fattest. CLPG lambs were significantly leaner than their D half-sibs for all measures of fatness ($P < 0.05$). The lower carcass fatness but greater muscularity is consistent with the findings of Abdulkhaliq et al. (2002), Jackson et al. (1993), and Snowder et al. (1994) for previous comparisons of CLPG lambs versus their normal half-sibs.

The greater fatness of T lambs compared to S lambs appears to disagree with the finding of Leymaster and Jenkins (1993) who reported that carcasses of T-sired and S-sired lambs did not differ in chemical fat composition when compared at a constant weight of 25 kg. The apparent discrepancy may be due to the heavier mean carcass weight (28.5 kg) in this trial. The previous report indicated that T-sired lambs grew more slowly (as was the case in this trial) but that the composition of their weight gain was lower in fat.

All indicators of fatness were higher for ewe lambs than for wethers with the differences being significant ($P < 0.05$) for FDR, FDB and USDA yield grade.

As shown in Table 3, the leaner CLPG carcasses resulted in heavier trimmed weights of shoulder, rack, sirloin, loin and leg ($P < 0.05$) but lighter shanks ($P < 0.05$) than the other genotypes. The other three genotypes differed little in trimmed weights for these cuts apart from leg and sirloin which followed the same order as leg scores with T > S > D.

The cumulative effect of heavier trimmed cuts resulted in CLPG carcasses producing over 70% of carcass weight as trimmed cuts compared to 66–68% for the other three genotypes ($P < 0.05$). Jackson et al. (1997) reported that Rambouillet ram lambs expressing the CLPG gene had an advantage in retail yield and carcass conformation when compared to non-CLPG siblings when slaughtered at 54.5 kg live weight. Busboom et al. (1999) likewise reported that CLPG phenotypes produced higher yields of wholesale leg, loin, rack and shoulder when compared to normal lambs.

In addition to having higher yield, CLPG carcasses had a greater proportion of trimmed weight as high-value cuts (62% versus 60% for the rest; $P < 0.05$), and the total value of trimmed cuts was more than \$6.5/carcass

Table 3
Least-square means (±S.E.M.) for weight of trimmed cuts adjusted for cold carcass weight, yield and proportion of high priced cuts, and net value of carcasses of normal (D) or Callipyge (CLPG) lambs sired by heterozygous Dorset rams and lambs sired by Texel (T) or Suffolk (S) rams

| Cut weight (kg) | Genotype | | | | S.E.M. | Gender | | S.E.M. |
|---|---|---|---|---|---|---|---|---|
| | D | CLPG | T | S | | Ewe | Wether | |
| Number | 33 | 49 | 52 | 55 | | 98 | 91 | |
| Neck | 0.49 b | 0.46 b | 0.47 b | 0.58 a | ±0.02 | 0.49 | 0.51 | ±0.01 |
| Shank | 0.86 b | 0.78 c | 0.92 ab | 0.96 a | ±0.01 | 0.87 a | 0.89 b | ±0.01 |
| Rack | 2.53 ab | 2.66 a | 2.46 b | 2.47 b | ±0.03 | 2.53 | 2.53 | ±0.02 |
| Sirloin | 1.29 c | 1.51 a | 1.41 b | 1.33 c | ±0.01 | 1.40 a | 1.37 b | ±0.01 |
| Leg | 5.27 c | 6.13 a | 5.70 b | 5.54 b | ±0.04 | 5.68 | 5.76 | ±0.03 |
| Loin | 2.18 b | 2.33 a | 2.21 b | 2.26 ab | ±0.02 | 2.26 | 2.23 | ±0.02 |
| Riblets | 1.10 | 1.10 | 1.09 | 1.06 | ±0.02 | 1.09 | 1.08 | ±0.01 |
| Shoulder | 5.01 c | 5.21 a | 5.18 ab | 5.13 b | ±0.04 | 5.03 a | 5.23 b | ±0.03 |
| % Trimmed cuts[a] | 65.70 c | 70.10 a | 67.80 b | 67.20 b | ±0.70 | 67.39 | 67.88 | ±0.22 |
| % High-value cuts[b] | 60.00 b | 62.20 a | 60.60 b | 59.70 b | ±0.70 | 61.21 a | 60.39 b | ±0.12 |
| Value ($) | 125.11 b | 135.79 a | 129.13 b | 127.95 b | ±0.64 | 129.30 | 129.80 | ±0.46 |

Means within a row and genotype or gender, with different letters differ at $P < 0.05$.
[a] Total weight of trimmed cuts/cold carcass weight.
[b] Weight of trimmed (leg + loin + rack + sirloin)/total weight of trimmed cuts.

Table 4
Least-square means (±S.E.M.) for weights and cooking characteristics of loin chops from carcasses of normal (D) or Callipyge (CLPG) lambs sired by heterozygous Dorset rams and lambs sired by Texel (T) or Suffolk (S) rams

| Trait | Genotype | | | | S.E.M. | Gender | | S.E.M. |
|---|---|---|---|---|---|---|---|---|
| | D | CLPG | T | S | | Ewe | Wether | |
| Number | 33 | 49 | 52 | 55 | | 98 | 91 | |
| Pre-cooked weight (g) | 132.1 b | 159.6 a | 134.2 b | 133.2 b | ±1.80 | 138.6 | 141.0 | ±1.30 |
| Cooked weight (g) | 92.9 b | 110.1 a | 95.2 b | 93.9 b | ±1.20 | 97.7 | 98.3 | ±0.30 |
| Cooking loss (%) | 29.6 b | 31.0 a | 29.0 b | 29.4 b | ±0.42 | 29.4 | 30.1 | ±0.31 |
| Cooking time (min) | 26.4 b | 32.0 a | 27.5 b | 27.1 b | ±0.54 | 27.9 | 28.5 | ±0.40 |
| Shear force (kg) | 2.9 b | 5.4 a | 2.8 b | 2.8 b | ±0.12 | 3.4 | 3.5 | ±0.08 |

Means within a row and genotype or gender, with different letters differ at $P < 0.05$.

greater than for the other genotypes ($P < 0.05$). T carcasses ranked second and D carcasses ranked lowest for both yield of trimmed cuts and carcass value.

Ewe lamb carcasses produced lower % trimmed cuts (a reflection of their greater fatness) but had a higher % of high-value cuts ($P < 0.05$). The two factors cancelled one another, resulting in no significant difference in carcass value between the two genders.

Characteristics of grilled loin chops are shown by lamb genotype and gender in Table 4. Chops from CLPG lambs were the heaviest pre-cooking, took the longest time to cook and yielded the heaviest cooked chops (all $P < 0.05$) despite also have the largest % cooking loss ($P < 0.05$). Shear force values of CLPG chops were nearly double those of the other genotypes ($P < 0.05$). No significant differences were observed among the other three genotypes for cooking results. The increased shear values and cooking losses of loin chops from CLPG lambs versus those from D lambs is consistent with the results of Meyer et al. (1995), although they observed no genotype effect when roasting selected leg muscles. Busboom et al. (1994) also reported higher cooking losses and greater shear values for CLPG versus normal lambs when loin chops were compared.

Gender had no effect on weights and cooking characteristics of loin chops.

## 4. Conclusion

The dramatic increase in muscle and decrease in fat resulting from the Callipyge gene offers a unique genetic means of improving lamb carcass cutability and value while producing the leaner meat desired by consumers. However, the increased meat toughness observed in grilled loin chops indicates a significant problem in product quality. Compared to the standard S and D lambs, T-sired lambs demonstrated leaner carcasses and an increase in carcass value at a constant weight with no evidence of reduced meat quality. This would seem to suggest a potential use for the Texels as terminal sire breed but must be balanced with slower growth and possible increased lamb survival when compared to S lambs.

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