Technical note: The United States Department of Agriculture beef yield grade equation requires modification to reflect the current longissimus muscle area to hot carcass weight relationship

T. E. Lawrence, R. L. Farrow, B. L. Zollinger and K. S. Spivey

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Technical note: The United States Department of Agriculture beef yield grade equation requires modification to reflect the current longissimus muscle area to hot carcass weight relationship

T. E. Lawrence,[1] R. L. Farrow, B. L. Zollinger, and K. S. Spivey

Department of Agricultural Sciences, West Texas A&M University, Canyon 79016-0001

ABSTRACT: With the adoption of visual instrument grading, the calculated yield grade can be used for payment to cattle producers selling on grid pricing systems. The USDA beef carcass grading standards include a relationship between required LM area (LMA) and HCW that is an important component of the final yield grade. As noted on a USDA yield grade LMA grid, a 272-kg (600-lb) carcass requires a 71-cm^2 (11.0-$in.^2$) LMA and a 454-kg (1,000-lb) carcass requires a 102-cm^2 (15.8-$in.^2$) LMA. This is a linear relationship, where required LMA = 0.171(HCW) + 24.526. If a beef carcass has a larger LMA than required, the calculated yield grade is lowered, whereas a smaller LMA than required increases the calculated yield grade. The objective of this investigation was to evaluate the LMA to HCW relationship against data on 434,381 beef carcasses in the West Texas A&M University (WTAMU) Beef Carcass Research Center database. In contrast to the USDA relationship, our data indicate a quadratic relationship [WTAMU LMA = 33.585 + 0.17729(HCW) – 0.0000863(HCW^2)] between LMA and HCW whereby, on average, a 272-kg carcass has a 75-cm^2 (11.6-$in.^2$) LMA and a 454-kg carcass has a 96-cm^2 (14.9-$in.^2$) LMA, indicating a different slope and different intercept than those in the USDA grading standards. These data indicate that the USDA calculated yield grade equation favors carcasses lighter than 363 kg (800 lb) for having above average muscling and penalizes carcasses heavier than 363 kg (800 lb) for having below average muscling. If carcass weights continue to increase, we are likely to observe greater proportions of yield grade 4 and 5 carcasses because of the measurement bias that currently exists in the USDA yield grade equation.

Key words: beef, yield grade, longissimus muscle area, hot carcass weight

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INTRODUCTION

For the majority of beef cattle slaughtered in the United States, carcass value has 3 determining factors: 1) weight, 2) an evaluation of intramuscular fat and physiological maturity, and 3) an estimate of the percentage yield of salable product. Trials conducted in the 1950s (Murphey et al., 1960) were compiled to develop the current USDA equation used to estimate the percentage of boneless, closely trimmed rib, loin, chuck, and round, which in turn provides the basis for the USDA yield grade equation. A change of one yield grade unit represents a 2.3% change in boneless, closely trimmed retail cuts from the round, loin, rib, and chuck (Murphey et al., 1960) or a 3.4% change in total retail product from the whole carcass (Dikeman et al., 1998). Hot carcass weight and LM area (**LMA**) are 2 of the 4 variables used to calculate the yield grade. A linear relationship was established that required a minimum LMA per unit of HCW. This relationship is reported on an official USDA LMA grid to facilitate the shortcut method of calculating yield grade.

During the 50 yr since the development of the yield grade equation, the cattle population and cattle feeding practices have changed significantly. Economic signals received by producers have placed greater emphasis on weight as a key driver of gross revenue. As such, selection for increased growth rate and lean muscle production has shifted the US genetic base from British (Hereford and Angus) to British × Continental influenced crossbreeds. Likewise, the expansion of the stocker segment has contributed to increased live weights of cattle entering feedlots (Sainz and Vernazza Paganini, 2004). Use of new visual electronic carcass evaluation methods allow the opportunity to measure and calculate the yield grade at production speeds; therefore, it is important to reevaluate the current system to ensure that

[1]Corresponding author: tlawrence@wtamu.edu
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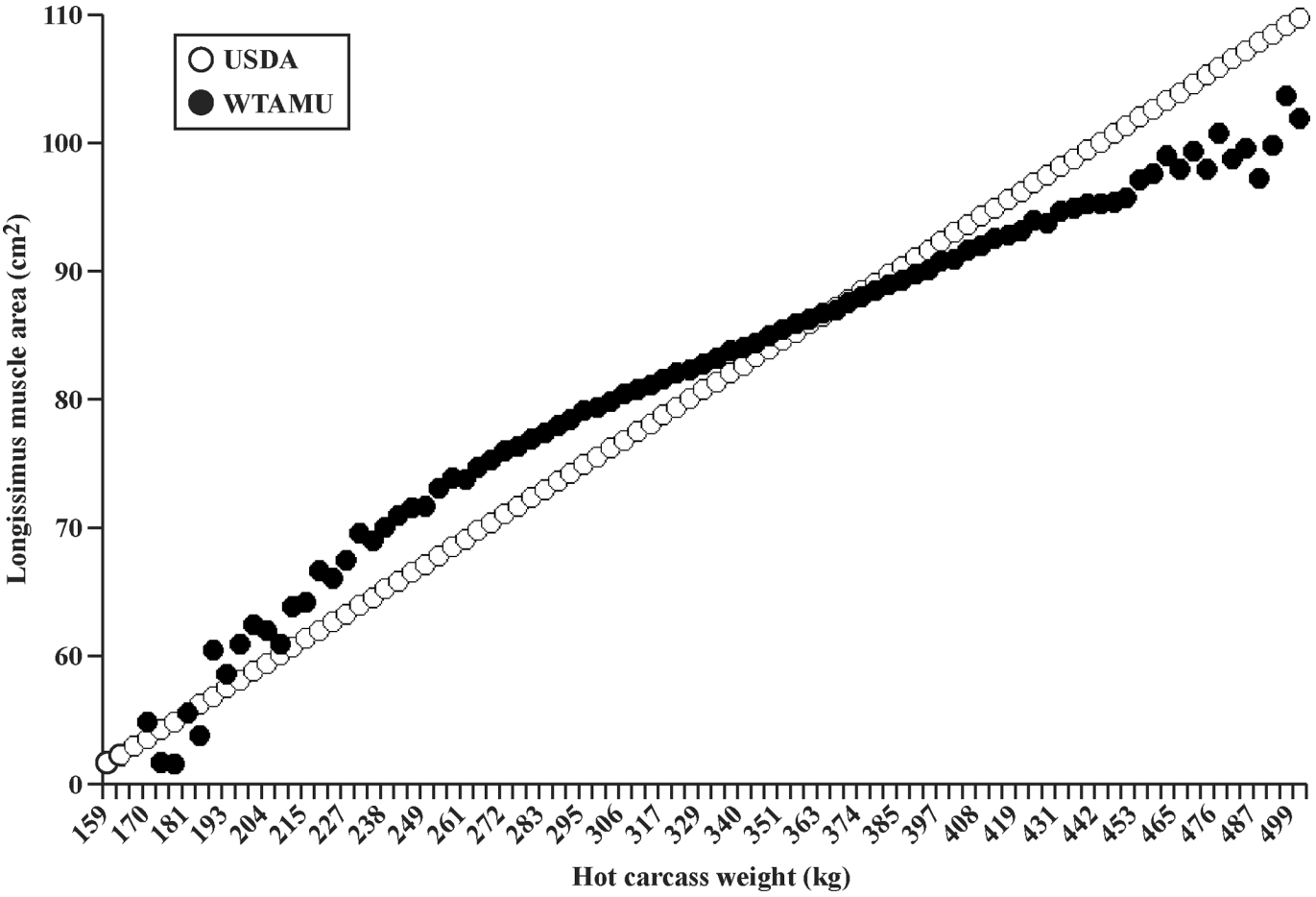

Figure 1. The USDA LM area per HCW relationship and the mean West Texas A&M University (WTAMU) LM area per HCW relationship.

the USDA continues to provide services that accurately reflect carcass yield. The objectives of this research note were to 1) evaluate the similarity between the official USDA HCW to LMA relationship and current data, and 2) establish a new relationship that more adequately represents the HCW to LMA relationship over a wide HCW range.

METHODS

Animal Care and Use Committee approval was not obtained for this study because the samples were obtained from federally inspected slaughter facilities.

Data Collection

During the period 1992 through 2006, beef HCW and LMA data were collected (n = 434,381) as part of the National Cattlemen's Association and National Cattlemen's Beef Association Cattlemen's Carcass Data Service and the West Texas A&M University (WTAMU) Beef Carcass Research Center. Hot carcass weights were recorded from the hot carcass scale or from official plant records. Longissimus muscle area images were captured by using electrophoretic blotting paper (LS-601-4657, Life Science Products Inc., Frederick, CO) and measured by using USDA ribeye area grids, digital planimeters, digital scanners, or computer-assisted drawing boards.

Statistical Analysis

Hot carcass weight and LMA data were analyzed by using regression techniques (PROC REG, SAS Inst. Inc., Cary, NC) to establish the relationship between HCW and LMA. Our data were compared with the official relationship reported on USDA LMA grids (i.e., a 272-kg carcass requires a 71-cm^2 LMA).

RESULTS

Visualization of the mean LMA values within HCW ranges (Figure 1) indicates a quadratic relationship between LMA and HCW whereby WTAMU LMA = 33.585 + (0.17729 × HCW) + (−0.0000863 × HCW^2); R^2 = 0.20. In contrast, regression analysis of the official USDA HCW and LMA requirement indicates a linear relationship whereby USDA LMA = 24.526 + (0.171 × HCW).

The USDA LMA grids list the required LMA for HCW from 158.73 to 498.64 kg. Our mean LMA data for each

Table 1. The USDA HCW ranges and required LM area (LMA) in comparison with West Texas A&M University (WTAMU) Beef Carcass Research Center data

USDA HCW range,[1] kg	USDA required LMA,[1] cm^2	WTAMU, n	Mean WTAMU LMA, cm^2	SD WTAMU LMA, cm^2
158.73–162.58	51.61	0	—	—
162.59–166.20	52.26	0	—	—
166.21–169.83	52.90	1	49.68	—
169.84–173.91	53.55	1	54.84	—
173.92–177.54	54.19	1	51.61	—
177.55–181.17	54.84	2	51.52	14.01
181.18–185.25	55.48	2	55.48	3.65
185.26–188.88	56.13	5	53.72	6.65
188.89–192.51	56.77	16	60.43	4.51
192.52–196.59	57.42	17	58.57	7.82
196.60–200.22	58.06	20	60.85	6.62
200.23–203.84	58.71	23	62.33	5.50
203.85–207.93	59.35	26	61.88	5.90
207.91–211.55	60.00	46	60.89	6.83
211.56–215.18	60.65	53	63.73	6.13
215.19–219.26	61.29	85	64.09	6.81
219.27–222.89	61.94	101	66.56	6.37
222.90–226.52	62.58	123	65.95	6.41
226.53–230.60	63.23	218	67.45	6.63
230.61–234.23	63.87	236	69.46	6.70
234.24–237.86	64.52	295	68.89	7.01
237.87–241.94	65.16	473	70.01	7.24
241.95–245.57	65.81	471	70.92	7.74
245.58–249.20	66.45	631	71.45	7.81
249.21–253.28	67.10	927	71.61	7.50
253.29–256.91	67.74	991	72.96	7.58
256.92–260.53	68.39	1,247	73.77	7.62
260.54–264.62	69.03	1,756	73.73	7.78
264.63–268.24	69.68	1,862	74.63	8.06
268.25–271.87	70.32	2,305	75.26	8.10
271.88–275.95	70.97	3,156	75.92	8.11
275.96–279.58	71.61	3,336	76.26	8.27
279.59–283.21	72.26	3,996	76.87	8.29
283.22–287.29	72.90	4,983	77.26	8.34
287.30–290.92	73.55	5,088	77.86	8.36
290.93–294.55	74.19	5,800	78.35	8.49
294.56–298.63	74.84	7,591	79.06	8.67
298.64–302.26	75.48	7,590	79.32	8.80
302.27–305.89	76.13	8,429	79.79	8.77
305.90–309.97	76.77	10,618	80.32	8.98
309.98–313.60	77.42	10,290	80.66	8.93
313.61–317.22	78.06	11,161	81.00	8.93
317.23–321.31	78.71	13,695	81.56	8.99
321.32–324.93	79.35	12,814	82.00	9.05
324.94–328.56	80.00	13,759	82.23	9.10
328.57–332.64	80.65	16,038	82.74	9.09
332.65–336.27	81.29	14,926	83.17	9.21
336.28–339.90	81.94	15,376	83.70	9.26
339.91–343.98	82.58	17,640	84.01	9.23
343.99–347.61	83.23	15,545	84.36	9.33
347.62–351.24	83.87	16,099	84.95	9.40
351.25–355.32	84.52	17,882	85.37	9.55
355.33–358.95	85.16	15,332	85.78	9.47
358.96–362.58	85.81	15,050	86.13	9.46
362.59–366.66	86.45	16,344	86.65	9.65
366.67–370.28	87.10	14,131	86.90	9.56
370.29–373.91	87.74	13,205	87.47	9.68
373.92–377.99	88.39	13,988	87.92	9.69
378.00–381.62	89.03	11,472	88.39	9.81
381.63–385.25	89.68	10,884	88.87	9.68
385.26–389.33	90.32	11,013	89.21	9.73
389.34–392.96	90.97	8,607	89.70	9.92

Continued

Table 1 (Continued). The USDA HCW ranges and required LM area (LMA) in comparison with West Texas A&M University (WTAMU) Beef Carcass Research Center data

USDA HCW range,[1] kg	USDA required LMA,[1] cm^2	WTAMU, n	Mean WTAMU LMA, cm^2	SD WTAMU LMA, cm^2
392.97–396.59	91.61	8,074	90.08	10.11
396.60–400.67	92.26	7,637	90.73	10.19
400.68–404.30	92.90	6,210	90.83	10.21
404.31–407.93	93.55	5,343	91.56	10.08
407.94–412.01	94.19	5,289	91.92	10.18
412.02–415.64	94.84	4,075	92.48	10.47
415.65–419.26	95.48	3,399	92.74	10.45
419.27–423.35	96.13	3,193	93.03	10.59
423.36–426.97	96.77	2,454	93.92	10.70
426.98–430.60	97.42	1,971	93.66	10.62
430.61–434.68	98.06	1,957	94.59	10.44
434.69–438.31	98.71	1,369	94.80	10.67
438.32–441.94	99.35	1,162	95.17	10.61
441.95–446.02	100.00	1,043	95.22	11.05
446.03–449.65	100.64	718	95.34	11.11
449.66–453.28	101.29	608	95.70	11.31
453.29–457.36	101.94	522	97.07	11.73
457.37–460.99	102.58	364	97.54	11.70
461.00–464.62	103.23	258	98.95	10.78
464.63–468.70	103.87	245	97.91	11.68
468.71–472.33	104.52	180	99.21	12.19
472.34–475.95	105.16	122	97.89	11.00
475.96–480.04	105.81	115	100.71	11.92
480.05–483.66	106.45	107	98.69	10.07
483.67–487.29	107.10	48	99.55	12.22
487.30–491.37	107.74	55	97.21	13.39
491.38–495.00	108.39	39	99.76	13.85
495.01–498.63	109.03	27	103.62	13.94
498.64–502.72	109.68	25	101.80	8.40

[1]These HCW ranges and required LMA represent those present on a USDA LMA dot grid (see text for further explanation).

HCW class (Table 1) suggest that, on average, carcasses with a HCW of less than 363 kg tend to have larger LMA than the USDA-required LMA and carcasses that have a HCW of greater than 363 kg tend to have smaller LMA than what is required. On the basis of these findings, carcasses that weigh 189 to 336 kg have calculated yield grades that are 0.1 to 0.2 units lower than expected, whereas carcasses that weigh 378 to 499 kg have calculated yield grades that are 0.1 to 0.5 units greater than expected. Therefore, heavier carcasses are more likely to result in yield grades of 4 and 5 because their LMA per HCW ratio requirement is overestimated.

DISCUSSION

Currently, the USDA model for the LMA to HCW relationship does not appropriately account for the actual rate of increase in LMA in relation to the increase in HCW. The USDA standard suggests that LMA increases at a linear rate as HCW increases. Our data indicate that the increase in LMA actually follows a typical growth curve and increases at a quadratic rate. However, the large amount of variation in LMA at each increment of HCW indicates that the relationship is poor, even in a large data set. These findings are supported by others ($r = 0.31$, Brungardt and Bray, 1963; $r = 0.45$, Birkett et al., 1965; $r = 0.48$, Epley et al., 1970; $r = 0.50$, Crouse et al., 1975), who have also reported a poor relationship between HCW and LMA. The perception throughout the beef industry is that HCW and LMA are linked in a significant manner. This perception is likely due to the assumed relationship predicated by the USDA yield grade equation. The reality is that the actual relationship is much weaker than we had anticipated.

The USDA HCW to LMA relationship has changed since its inception, and carcasses in the upper weight range were uncommon when the research was conducted to determine USDA yield grades. Based on our data, the portion of carcass value attributable to estimated red meat yield could be misinterpreted because of the inaccuracy of the current USDA HCW to LMA relationship. Within the USDA yield grade formula, the difference in average LMA and required LMA provides evidence for a muscling bias that favors light carcasses and penalizes heavy carcasses. This scenario may explain the 10% increase in yield grade 4 and 5 cattle, which has been accompanied by an 11% increase in carcass weights between 1996 and 2006 (USDA, 2006). If cattle size and carcass weights continue to increase,

this issue requires the attention of USDA, the commercial beef industry, and the cattle-feeding industry.

Correcting the required LMA per HCW relationship should help recognize the actual value of carcasses. The relationship change would add value to heavier carcasses that had previously been penalized. In contrast, the value of some lighter weight carcasses would decrease as a result of correctly accounting for an appropriate LMA per HCW relationship. Although incorporating this new formula could prove to be difficult, it carries significant economic impact. Considerable changes could be made in cattle feeding and marketing based on their weight. This new knowledge suggests that if cattle are fed to heavier carcass weights, they will have less value, likely because of a numerical increase in yield grade.

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