A survey of lamb carcass characteristics in the Intermountain West during periods of seasonally constrained supply

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INTRODUCTION

Seasonality of production is an inherent issue unique to the lamb industry as approximately 85% of lambs in the United States are born in the first 5 mo of the year (USDA APHIS, 2011). Ideally, lambs are harvested between 6 and 12 mo of age leading to shortages in lamb supply from May to August (USDA ERS, 2018). However, the lamb packing industry requires a continual supply, and in order to compensate for supply shortages feedlots must extend days on feed, pushing lambs beyond weights appropriate for their frame size. The demand for production efficiency has also driven selection toward rapid growth rates and larger framed sheep. These factors in part lead to inconsistencies in the quality of lamb during summer months when supply is seasonally constrained. Sheep industry working groups have identified lamb products excessive in fat as a major threat to consumer satisfaction and demand for American lamb (American Sheep Industry, 2014). Currently, the U.S. lamb industry follows a value-based pricing system on a limited basis with the primary emphasis on hot carcass weight (HCW) and USDA yield grades (USDA YG), leaving the packer to bear the additional expenses generated from excessively large lamb carcasses. To date, there has been no quantification of the accrued costs of excessively finished lamb carcasses in the U.S. processing sector. The broad objectives of this pilot study were to quantify carcass characteristics during the most seasonally constrained supply periods of the year to better assess adverse impacts of production seasonality on lamb quality characteristics. Relatedly, the specific objective herein was to evaluate current carcass quality in the U.S. lamb industry as part of a larger long-term study assessing the economic impacts of excessively finished lambs in the U.S. industry.

MATERIALS AND METHODS

This project was conducted in cooperation with Mountain States Lamb, Greeley, CO and Superior Farms, Denver, CO abattoirs. Approximately 5% of the weekly lamb harvest in the Intermountain West region was surveyed from May 24 to August 17, 2018, with a total of 7,378 lamb carcasses being evaluated. Data were collected on all carcasses fabricated in the plant each data collection day, including carcasses classified as mutton. There were mutton carcass ($n = 805$) images analyzed, but the data were omitted from statistical analysis. Immediately after the carcass was cut between the 12th and 13th rib, a digital image was taken using a 24-megapixel digital camera. The camera was mounted on an aluminum support bar with an aluminum cross bar and perpendicular bolt for stabilizing the camera and ensuring uniform distance

from the carcass. The perpendicular bolt was aligned with the midline. The USDA YG and USDA quality grade were assigned by trained personnel according to USDA (1992) guidelines. USDA YG yield and USDA quality grade were recorded on the carcass tag, and the carcass tag was held within the image frame in order to capture HCW, USDA YG, USDA quality grade, and image-based camera grade. The ruler edge of a rib eye area grid was also held level with the cut surface of the carcass for calibration reference points during image analysis. Pictures were taken at production speed over 18 full working days between May and August. Measurements were obtained from the digital images using ImageJ software (v.1.52a; NIH, 2018) included 12th-rib fat depth, longissimus muscle area (LMA), and body wall thickness. At the approximate midpoint of the LM 12th-rib fat depth was measured and body wall thickness was measured at approximately 12.7 cm from the dorsal midline. All measurements were taken from both sides and averaged. Calculations included calculated percentage boneless, closely trimmed retail cuts (%BCTRC) and calculated yield grade (CalYG). Calculated %BCTRC was calculated using formula 1 (Tschirhart et al., 2002) and CalYG using formula 2 (USDA, 1992):

$$\%BCTRC = 49.936 - (0.0848 \times HCW, \text{ lb})$$
$$- (4.376 \times \text{12th-rib fat, in})$$
$$- (3.53 \times \text{body wall thickness, in})$$
$$+ (2.456 \times LMA, \text{ in}^2) \qquad (1)$$

$$CalYG = (\text{12th-rib fat (in)} \times 10) + 0.4 \quad (2)$$

Frequency analysis and Pearson correlation analysis were conducted using SAS (v.9.4; SAS Institute Inc., Cary, NC). Descriptive statistics of lamb carcass characteristics were analyzed using the MEANS procedure of SAS.

RESULTS AND DISCUSSION

A common, easily measured carcass trait is HCW. Field and Whipple (1998) reported that average U.S. lamb carcass weight in 1988 was 28.6 kg (63 lb). Our data show that lamb HCW averaged 40.21 ± 9.37 kg (88.65 ± 20.66 lb) (Table 1) and 87% of exceed 30 kg (Figure 1A). Carcass weight was reported highly correlated to LMA, 12th-rib fat, and body wall thickness (Table 2). Body wall thickness was the most highly correlated trait with HCW (0.75, $P < 0.001$). This would suggest that lamb carcass weights have increased since 1988, however, in this study carcass weights were only measured during the summer months and should be interpreted judiciously as these data likely differ from winter and spring months when the industry is more current in its harvest supply.

USDA reported an industry target for 12th-rib fat as 6.4 mm or one-fourth inch (USDA, 1992). Carcasses surveyed that exceeded 6 mm of 12th-rib fat comprised 67.5% of the samples as reported in Figure 1B with mean 12th-rib fat reported as 7.86 ± 3.63 mm (Table 1). Whole lamb carcasses destined for shipment require greater protection from subcutaneous fat, but industry retail specifications require trimming to 3.2 mm (1/8 in). On the basis of estimates in the current study, 87.9% of lamb carcasses would require trimming to some degree. It's unclear the extent to which the abattoir prioritizes or achieves this industry specified 3.2 mm trim given 87.9% of surveyed carcasses exceeded 3.2 mm; it's clear that quality control with trimming requires significant attention. In addition, 12th-rib fat and body wall thickness are highly correlated (0.64, $P < 0.001$). Body wall thickness averaged 31.35 ± 9.04 mm. A low, positive correlation was found between 12th-rib fat and LMA (0.19, $P < 0.001$) and a moderate, positive relationship was reported between body wall thickness and LMA (0.48,

Table 1. Lamb carcass characteristics ($n = 6{,}573$) in the Intermountain West during periods of seasonally constrained supply (May to August)

Carcass trait[1]	Mean	SD	Median	Min	Max	Range
HCW, kg	40.21	9.37	39.68	14.95	85.49	70.54
12th-rib fat depth, mm	7.86	3.63	7.38	0.00	33.15	33.15
Body wall thickness, mm	31.35	9.04	30.25	7.29	76.09	68.80
%BCTRC[2]	43.70	3.23	43.55	27.26	54.37	27.10
USDA yield grade	3.31	0.95	3.00	0.00	5.00	5.00
Image-based yield grade	4.43	1.43	4.40	0.00	8.90	8.90
Calculated yield grade	3.49	1.43	3.30	0.40	13.45	13.05
LM area, cm²	16.83	3.15	16.61	7.16	33.79	26.63

[1]Measures of LM area, 12th-rib fat, and body wall thickness were taken between the 12th and 13th ribs of both sides and averaged for analysis.
[2]Calculated %BCTRC = calculated percentage of boneless, closely trimmed retail cuts.
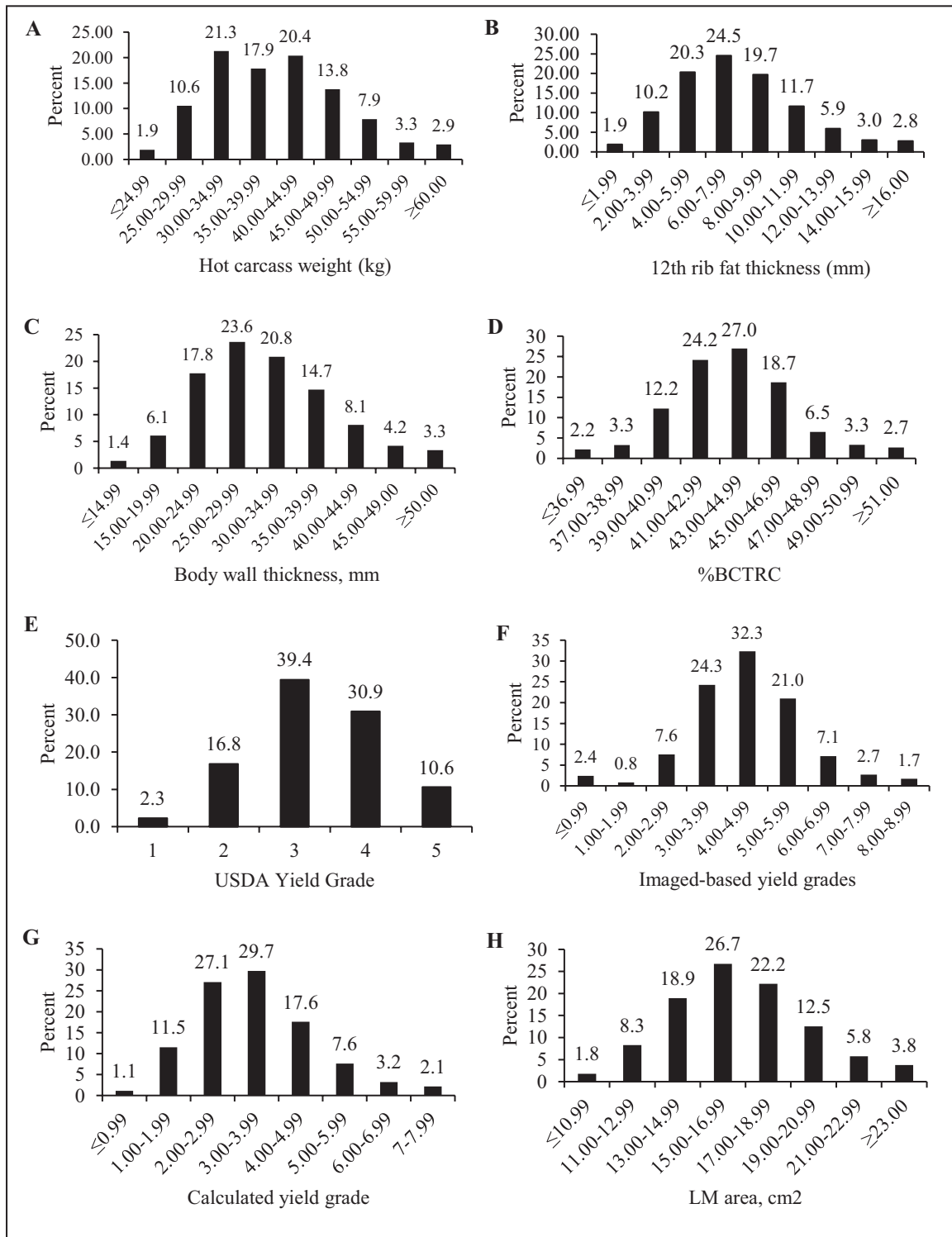
Figure 1. Frequency distributions of hot carcass weight (A), 12th-rib fat (B), body wall thickness (C), %BCTRC (D), USDA yield grade (E), image-based yield grades (F) calculated yield grade (G), and LM area (H) in lambs (*n* = 6,573) harvested from May to August.

$P < 0.001$). These results suggest that red meat yield increases at a slower rate compared to subcutaneous fat deposition as lambs are fed for longer periods. These results are supported by Field and Whipple (1998), as they reported that there is a positive relationship between degree of fatness and carcass weight. Although the relationship between fat deposition and palatability is a current topic of debate, Jeremiah (1993) found that increased adipose deposition negatively affected consumer acceptance.

In order to meet consumer demand and ensure processing plant profitability, emphasis should be placed on raising lambs that are reaching ideal compositional endpoints, that is, adequate lean muscle

Table 2. Estimated Pearson correlation coefficients between lamb carcass characteristics (*n* = 6,573) in the Intermountain West during periods of seasonally constrained supply (May to August)[1]

	HCW	LM area	12th-rib fat depth	Body wall thickness
HCW	1.00	0.56	0.57	0.75
LM area	0.56	1.00	0.19	0.48
12th-rib fat depth	0.57	0.19	1.00	0.64
Body wall thickness	0.75	0.48	0.64	1.00

[1]Estimated Pearson correlation coefficient is different than 0 ($P < 0.0001$).

with appropriate external fat (Jeremiah, 1997). A good metric for estimating saleable lean product is %BCTRC. Most (51.3%) of the lamb carcasses surveyed fell between 41% and 45%BCTRC (Figure 1D). The variation seen in HCW, 12th-rib fat, and body wall thickness alters cutability and negatively affects %BCTRC, thereby, reducing marketable red meat and shrinking margins for the processing plant.

Wide ranges in values were also seen in all yield grading methods. Mean USDA YG was a 3.31 ± 0.95. Instrument grading assigns yield grades ranging from 0.0 (unrecognizable to image-based grading apparatus) to 8.9. Current data reported average image-based yield grade (ImYG) of 4.43 ± 1.43, and mean CalYG was a 3.49 ± 1.43. As reported in Figure 1, irrespective of the method used for estimating yield grade, 41.5%, 65.0%, and 30.6% of USDA grade, ImYG, and CalYG, respectively fell into yield grades 4 and above. Continuity of current grading systems and average yield grades is needed, especially as pricing grids use yield grade. Improving current yield grading techniques will help disincentivize prolonged feeding time and reduce excessively fat lamb carcasses. Carpenter (1966) reported that more research is needed to examine the subjective measures of quality and conformation currently used by the industry and develop objective guidelines to balance carcass weight and yield of retail cuts.

Large sheep operations (1,000 head or more) in the Intermountain West with a white-faced, fine wool base flock are the largest contributors of slaughter lambs in the United States. (USDA APHIS, 2011). Ewes are bred to terminal-type rams to produce offspring more suited for meat production. These crossbred lambs are the primary source of American lamb. However, they are not as heavily muscled as purebred terminal lambs. It is widely hypothesized in the American lamb industry that increased slaughter weights result in increased LMA. Pearson correlation coefficients in Table 2 support this assumption, reporting a high, positive correlation (0.56, *P* < 0.001) between HCW and LMA. This survey data found that average LMA was 16.83 ± 3.15 cm² (2.61 ± 0.49 in²).

Recent industry assessment has indicated a need to pursue a consumer-driven product that is not excessive in fat content. An important step in improving lamb demand is decreasing the level of variability of carcasses through value-based pricing (American Sheep Industry, 2014). The high level of variation in lamb carcasses during seasonally constrained supplies, as displayed in these results, provides preliminary, quantitative data that can be used to initiate industry-wide lamb product improvement.

IMPLICATIONS

Seasonality of production in the U.S. lamb industry leads to market volatility affecting all sectors of the American Sheep Industry supply chain (e.g., ewe–lamb operations, lamb feeders, abattoir, and consumer). The findings of this survey data provide quantitative data which reveals that carcass weights are greater than preferred and carcass composition is higher in external fat during the season of reduced supply. Further investigations will evaluate carcass characteristics from September to May during the seasonal time points when lamb supplies are more current and carcass characteristics are expected to be within acceptable ranges. Concurrent data collection at the plant level and economic analysis will calculate the cumulative cost of excessively finished lambs to the industry. Results will be used in extension and educational programs to help inform sheep producers and industry professionals of the impacts of excessively finished lambs to all production segments of the U.S. lamb industry.

Conflict of interest statement. None declared.

LITERATURE CITED

American Sheep Industry. 2014. The American Lamb Industry Roadmap. Englewood, COAmerican Sheep Industry. [accessed February 4, 2019] https://lambresourcecenter.com/wp-content/uploads/2015/09/Lamb-Industry-Roadmap-3-Jan-2014.pdf

Carpenter, Z. L. 1966. What is consumer-preferred lamb?. J. of Anim. Sci. 25:1232–1235. doi:10.2527/jas1966.2541232x

Field, R. A., and G. Whipple. 1998. The relation of slaughter and carcass weights to production and processing efficiency and market acceptability. Sheep and Goat Res. J. 14:98–105.

Jeremiah, L. E. 1997. Development of a quality classification system for lamb carcasses. Meat Sci. 48:211–223. doi:10.1016/S0309-1740(97)00095-8

Jeremiah, L. E., L. L. Gibson, and A. K. W. Tong. 1993. Retail acceptability of lamb as influenced by gender and slaughter weight. Food Res Int. 26:115–118. doi:10.1016/0963-9969(93)90066-R

NIH. 2018. ImageJ News. Bethesda (MD): National Institutes of Health. –[accessed February 13, 2019].https://imagej.nih.gov/ij/notes.html.

Tschirhart, T. E., L. A. Rakowitz, D. R. McKenna, D. B. Griffin, J. W. Savell. 2002. Development of a cutability equation for carcasses of show lambs. Sheep and Goat, Wool and Mohair CPR. 2002:31–35.

USDA APHIS. 2011. Part IV: Changes in health and production practices in the U.S. sheep industry, 1996–2011. Washington (DC): APHIS, USDA.

USDA ERS. 2018. Livestock and Poultry Slaughter. [accessed May 9, 2019]. https://www.ers.usda.gov/data-products/livestock-meat-domestic-data/livestock-meat-domestic-data/.

USDA. 1992. Official United States standards for grade of lamb, yearling mutton, and mutton carcasses. Washington (DC): AMS, USDA.