DEVELOPMENT AND VALIDATION OF EQUATIONS UTILIZING LAMB VISION SYSTEM (LVS) OUTPUT TO PREDICT LAMB CARCASS FABRICATION YIELDS

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The need in the North American lamb industry for an objective and accurate method of predicting red meat yield, as well as the true value of lamb carcasses, has long been acknowledged. Brady et al. (2002) studied the ability of the lamb vision system (LVS; Research Management Systems USA, Fort Collins, CO) to predict fabrication yields of lamb carcasses; results of that study demonstrated that LVS is capable of predicting fabrication yields and, thus, true monetary values of lamb carcasses more accurately than does the current system of lamb pricing – which is based primarily on carcass weight and USDA Yield Grades.

This study was performed to develop and evaluate regression equations that utilize the dual-component Lamb Vision System (hot carcass and chilled carcass ribeye imaging components) to predict fabrication yields of lamb carcasses with the intent of accurately assigning monetary value to lambs in a commercial packing plant. Lamb carcasses (N = 149) were selected by Colorado State University (CSU) personnel, imaged using the LVS hot carcass component, and chilled for 24 to 48 h. Chilled carcasses were assigned On-Line USDA Yield Grades (at chain speeds, by regular plant graders) and Expert USDA Yield Grades (by grading supervisors, with unlimited time and access to the carcasses); grade factors and/or the grade were recorded for each carcass. Before fabrication, carcasses also were assessed using the LVS-Ribeye imaging component. Carcasses were fabricated into bone-in subprimal/primal cuts. Yield data for an individual carcass was included in the study only if the aggregate sum of weights for all parts of that carcass totaled at least 98% of its initial chilled carcass weight. The following yields were calculated for each carcass: (a) "saleable meat yield", which refers to bone-in subprimal/primal cuts plus lean trim from the leg, loin, rack and shoulder, along with thin cuts, as a percentage of chilled carcass weight; (b) "subprimal yield", which refers to the bone-in cuts from the leg, loin, rack, and shoulder as a percentage of chilled carcass weight; and (c) "fat yield", which refers to the trimmable fat generated from the production of subprimal/primal cuts as a percentage of chilled carcass weight.

On-Line (whole-number) USDA Yield Grades accounted for 58.9%, 58.5% and 64.5% of the observed variability in saleable meat yields, subprimal yields, and fat yields, respectively. Expert (whole-number) USDA Yield Grades explained 59.0%, 58.6% and 64.9% of the observed variability in saleable meat yields, subprimal yields, and fat yields, respectively. Expert (nearest-tenth) USDA Yield Grades accounted for 60.0%, 59.8% and 67.3% of the observed variability in saleable meat yields, subprimal yields and fat yields, respectively.

The best prediction equation developed in this trial using LVS output (hot-carcass component only) and hot carcass weight as independent variables explained 67.6% of the variation in saleable meat yields, which was a 9 percentage point improvement compared to the accuracy of On-Line (whole-number) USDA Yield Grades, a 7 percentage point improvement compared to Expert (nearest-tenth) USDA Yield Grades, and an 8 percentage point improvement compared to Expert (whole-number) USDA Yield Grades. The LVS prediction equation accounted for 61.9% of the subprimal yields, which was an improvement of 3 percentage points in comparison to On-Line (whole-number) USDA Yield Grades, a 3 percentage point improvement compared to Expert (nearest-tenth) USDA Yield Grades, and a 3 percentage point improvement compared to Expert (whole-number) USDA Yield Grades. In addition, the Lamb Vision System prediction equation explained 73.8% of the variation in fat yields, which was a 9 percentage point improvement over the predictive ability of On-Line (whole-number) USDA Yield Grades, a 6 percentage point improvement over the predictive ability of Expert (nearest-tenth) USDA Yield Grades, and a 9 percentage point improvement compared to Expert (whole-number) USDA Yield Grades. Applying the newly developed best-fit regression equation to the data collected from lamb carcasses by Brady et al. (2002) explained 59.4%, 54.8% and 75.4% of the variability in saleable meat yield subprimal yield, and fat yield, respectively. Table 1 presents R^2, root mean square error (RMSE) and predicted residual sum of squares (PRESS) statistics, and the coefficients used for the prediction equations in both of the two studies. Coefficients for independent variables in the regressions equations were allowed to differ between the studies due to hardware and software adjustments incorporated into the LVS system in the time lapse between conduction of this study and the Brady et al. (2002) study.

The addition of output from the ribeye imaging component of LVS (longissimus muscle area = LMA and overall percent fat in the 12th/13th rib interface), improved predictive accuracy of the equations; the combined output equations explained 71.9% and 65.6% of the variability in saleable meat yield and subprimal yield, respectively (Table 2). Accuracy and repeatability of the measurements of LMA made with the cold-carcass system also were assessed; results suggested that use of LVS results provides reasonably accurate (R^2=0.59), but highly repeatable, measurements of LMA (repeatability = 0.98).

The LVS output, along with hot carcass weight, also was used to predict the weight of each primal cut from each carcass. Lamb Vision System prediction equations explained 88.3%, 78.1%, 68.0%, and 82.6% of the variation in weights of bone-in shoulders, racks, loins, and legs, respectively.

Use of the LVS to predict bone-in cut yields of lamb carcasses improved accuracy and precision compared to On-Line (whole-number), Expert (whole-number), or Expert (nearest-tenth) USDA Yield Grades. When used alone, or in combination with the output from the cold carcass ribeye imaging system, use of LVS output enhanced on-line estimation of boneless cut yields from lamb carcasses. Accuracy and repeatability of LVS output for predicting weight and/or yields of wholesale cuts suggests that this system could be used as an objective means for pricing carcasses in a value-based marketing system.

References

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Table 1. Independent variables, R^2, root mean square error (RMSE) values, and predicted residual sum of squares (PRESS) statistics for best-fit regression equations developed to predict percent carcass side yields using lamb vision system (hot carcass component) output plus hot carcass weight, developed in the present study and applied to the data from Brady et al. (2002).

Dependent variables	Present study				Applied to Brady et al. (2002)			
	R^2	RMSE	PRESS	Variables in model (coefficient)[f]	R^2	RMSE	PRESS	Variables in model (coefficient)[f]
Saleable meat yield, %[a]	0.676	0.021	0.069	HCW (-0.0021), CxsLen (0.000015), Sh/Ra ratio(0.26647), Tw ratio(-0.25329), GrRtLeg(0.000447), Lw1(0.00064), ShBi (0.53452)	0.594	0.022	0.119	HCW(-0.0018), CxsLen (0.0003044), Sh/Ra ratio(0.21675), Tw ratio (-0.14012), GrRtLeg(0.0000093), Lw1 (0.00024), ShBi (1.50988)
Subprimal yield, %[b]	0.619	0.017	0.045	HCW (-0.00129), CxsLen (0.000087), Sh/Ra ratio(0.22107), Tw ratio(-0.21053), GrRtLeg(0.000273), Lw1(0.000311), ShBi (0.6423)	0.548	0.021	0.112	HCW (-0.00166), CxsLen (0.0003042), Sh/Ra ratio (0.2101), Tw ratio (-0.14084), GrRtLeg (-0.000008) Lw1 (-0.000102244), ShBi (1.11035)
Fat yield, %[c]	0.738	0.021	0.068	HCW (0.00267), CxsLen (-0.00016), Sh/Ra ratio (-0.27358), Tw ratio (0.2555), GrnAng1(0.00226), Lw1(-0.00076288), ShBi (-0.46843)	0.754	0.024	0.142	HCW (0.00287), CxsLen(-0.0003202), Sh/Ra ratio (-0.2937), Tw ratio (0.19025), GrnAng1(0.00227), Lw1 (-0.00085889), ShBi (-1.56582)

[a]Saleable meat yield = subprimal cuts and lean trim from the leg, loin, rack, shoulder, and thin cuts as a percentage of chilled side weight.
[b]Subprimal yield = subprimal cuts from the leg, loin, rack, and shoulder as a percentage of chilled side weight.
[c]Fat yield = percentage of chilled side weight of fat from the production of subprimal cuts.
[f]HCW = hot carcass weight, CxsLen = carcass length, GrRtLeg = groin to right leg length, ShBi = blue color score for shoulder (adjusted for intensity), Sh/Ra ratio = ratio of the maximum rack width and maximum shoulder width, Tw ratio= ratio of the minimum body (shoulder, rack, loin) and the maximum body width, Lw1 = leg width measurement closest to the groin, GrnAng1= first groin angle measurement.

Table 2. Independent variables, R^2, root mean square error (RMSE), predicted residual sum of squares (PRESS) and partial R^2 for regression equations using lamb vision system (LVS) factors, HCW, and LMA and/or percent fat (PF) measurements from the video image analysis (VIA), to predict saleable meat [a] and subprimal [b] yields from lamb carcasses.

Dependent Variables	R^2	RMSE	PRESS	Variables in model[c] (Partial R^2)
Saleable meat yield, % [a]	0.7189	0.0192	0.0587	% Fat(0.5258), HCW (0.0650), CxsLen (0.0677), Sh/Ra ratio (0.0198), Tw ratio (0.0101), GrRtLeg (0.0247), Lw1(0.0058)
Subprimal yield, % [b]	0.6562	0.0159	0.0401	% Fat (0.4678), HCW (0.0627), Sh/Ra ratio (0.0431), Tw ratio (0.0197),GrAng1 (0.0483), ShBi (0.0145)

[a]Saleable meat yield: subprimal cuts and lean trim from the leg, loin, rack, shoulder, and thin cuts as a percentage of chilled carcass weight.
[b]Subprimal yield: subprimal cuts from the leg, loin, rack, and shoulder as a percentage of carcass side weight.
[c]HCW = hot carcass weight, CxsLen = carcass length, GrRtLeg = groin to left leg length, ShRi = red color score for shoulder (adjusted for intensity), ShBi = blue color score for shoulder adjusted for intensity, LMA = longissimus muscle area obtained from Video Image Analysis (VIA), Percent Fat= Overall percent fat in the 12th /13th rib interface obtained from VIA output, Sh/Ra ratio = ratio of the maximum rack width and maximum rhoulder width, Tw ratio= ratio of the minimum body width (shoulder, rack, loin) and the maximum body width, Lw1 = leg width measurement closest to the groin, GrAng1= first groin angle measurement.