An Evaluation of the Lamb Vision System as a Predictor of Lamb Carcass Red Meat Yield Percentage[a]

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SUMMARY

An objective, accurate method for predicting red meat yield in lamb carcasses is needed to improve assessment of true carcass value. This study was performed in order to evaluate the ability of the Lamb Vision System (LVS) to predict, accurately, fabrication yields of lamb carcasses. Lamb carcasses (N = 246) were scanned by the LVS, and output values were assigned to each carcass. Online and expert USDA Yield Grades were assigned to carcasses. Lamb carcasses were fabricated into bone-in and boneless wholesale cuts to determine subprimal yields. The best regression prediction equation, developed using LVS and hot carcass weight (HCW), explained 63% and 62% of the variation in boneless and bone-in saleable meat yields, respectively. LVS output also was used to predict weights of the four primals, and explained 77%, 65%, 87%, and 95% of the variation in weights of boneless shoulders, racks, loins, and legs, respectively, as well as 84%, 62%, 72%, and 85% of the variation in weights of bone-in shoulders, racks, loins, and legs, respectively. Lamb Vision System is an accurate method of predicting subprimal yields and pounds of wholesale cuts; thus, this system could be used to price carcasses more objectively in a value-based pricing system.

Key Words: Lamb Vision System, Subprimal Yields, Lamb Carcasses

INTRODUCTION

It has long been apparent and well documented that the U.S. sheep industry deserves criticism for the production of excessively fat sheep. In a nation-wide survey, Tatum et al. (1989) explicitly stated that the majority of U.S. lamb carcasses were excessively fat externally. In addition, Beerman et al. (1995) reported that the lamb industry had made relatively little progress in improving the composition of slaughter lambs. Thus, there still remains a need to discover an objective, accurate method to predict lean meat yield that will also serve as an objective method for assigning values to lamb carcasses. Previous beef research (Cannell et al., 1999, Steiner et al., 2000) suggests that accurate prediction of lean meat yield can be obtained using instruments, and therefore, can also be used in value assessment. The objective of this study was to determine if the Lamb Vision System (LVS) could be used to accurately predict carcass cutability in a commercial setting, and therefore, carcass value.

MATERIALS AND METHODS

Carcass Selection. Lamb carcasses (N = 246) were selected at a commercial packing plant after slaughter to fill blocks of sex class (ewe and wether), carcass weight (light - ≤ 65 lbs, medium – 66 to 75 lbs, heavy - ≥ 76 lbs), Yield Grade (1 through 5), and degree of muscling (light or heavy) subclasses within Yield Grade. Lamb carcasses included in this study reflected the range of variation in carcass traits experienced at the commercial facility each week. Immediately following selection, carcasses were scanned using the LVS, and images, HCW and carcass ID were stored. Carcasses were then moved to the chilling cooler for 24 h, except during weekends (72 h).

Carcass Grading. Following chilling, all carcasses were circulated past the grading stand at normal chain speeds (~ 480 hd/h), and a USDA grader assessed and stamped a USDA Quality and Yield Grade on each carcass. The carcasses were then evaluated by an expert USDA grader for Quality and Yield Grade factors, as well as a final USDA Quality and Yield Grade. These “Gold Standard” Yield Grades and factors were used to determine which carcasses fit the project design. Selected carcasses were then fabricated such that one side of each carcass was fabricated into boneless subprimal cuts, and the other side into bone-in subprimal cuts.

Cutability Test. Cold carcass weights were obtained on all carcasses prior to fabrication. All carcasses were separated between the 12th and 13th ribs. Following this separation, ribeye area measurements were recorded for half of the total number of carcasses (N = 124). Each fore- and hind-quarter was then further divided into shoulder, rack, loin, and leg primals. The primals were then split and separated, according to fabrication style (boneless vs. bone-in). Closely trimmed (0.125 in) boneless subprimal cuts generated in this study were: boneless square-cut shoulder, (NAMP 207), ribeye roll, boneless loin, full tenderloin, sirloin (NAMP 245), boneless leg (NAMP 233B), and boneless breast. Closely-trimmed bone-in subprimal cuts generated in this study were: square-cut shoulder (NAMP 207), neck, foreshank (NAMP 210), breast (NAMP 209), Denver ribs (NAMP 209A), split and chined rack (NAMP 204A), 1 in x 1 in block ready loin, leg (NAMP 233C), neck, and hindshank (NAMP 233E). All carcasses in the study had final weighbacks of at least 97% of the initial chilled carcass weight.

Statistical Analyses. All statistical analyses, including principle components analysis, and multiple regression, were performed using the SAS system (Cary, NC).

RESULTS

On-line USDA Yield Grade, expert USDA Yield Grade calculated to the whole number, and expert USDA Yield Grade calculated to the tenth of a grade unit were all regressed on

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[a] The authors would like to acknowledge the assistance of ConAgra Foods and Rosen of Colorado for providing access to their facilities in the completion of this project.

boneless and bone-in carcass yields (Table 1). Expert USDA Yield Grade (calculated to the whole number) prediction equations explained more of the variation in bone-in saleable yield than the variation in boneless lean meat yield. Actual yields of the bone-in cuts were less variable, as seam fat, bone, and lean trim remained intact with the subprimal cuts, and were not contributors to the variation in lean meat yield as with the boneless side yields. Thus, regression functions explained less total variability in bone-in saleable yields, and had higher R^2 values than the best fit regression equation for predicting boneless lean meat yields using USDA expert Yield Grades.

The USDA Yield Grades assigned by the Expert Grader and calculated to the tenth of a grade unit were more accurate in predicting fabrication yields than were either online or expert USDA Yield Grades calculated to the whole number.

Online USDA Yield Grades (whole-number) explained similar proportions of variation in fabrication yields to the expert whole number Yield Grades, with similar precision, and both appeared to explain less variation in fabrication yields than Expert Yield Grades calculated to the tenth of a grade unit.

Thus, expert Yield Grades to the whole number and on-line Yield Grades differed little in the prediction of red meat yield. These findings supported those of Heaton et al. (1993), who reported that on-line visual assessments of Yield Grades in lamb carcasses are very similar to Expert USDA Yield Grades when assigned to carcasses as whole numbers.

Regression equations developed to predict fabrication yields using LVS output and hot carcass weight are presented in Table 2. Inclusion of carcass weight in the prediction models supported the findings of Garrett et al. (1992) who reported that carcass weight is an important factor to be included as it is highly correlated to lamb carcass yields.

The best regression equation developed to predict lean meat yield for boneless carcass sides accounted for 63% of the observed variability, while the best regression equation developed to predict bone-in saleable meat yield accounted for approximately 62% of the variability. Thus, contrary to the regression equations presented in Table 1, where Yield Grade (expert to the whole number, expert to the tenth of a grade unit, and on-line) explained more of the variation in bone-in compared to boneless saleable yield, LVS output plus HCW explained a greater proportion of the variation in boneless lean meat yield compared to bone-in saleable meat yield. Therefore, LVS explained a larger proportion of the variation in the more variable boneless yields than in the less variable bone-in yields. Best-fit LVS models for fat yields explained 77% and 75% of the proportion of variation in trimmable fat yields generated from boneless and bone-in fabrication styles, respectively. These figures were noteworthy, as the current USDA Grade Standards are based solely on a fat thickness measurement. Thus, with most of the variability in lamb carcass cutability believed to be due to differences existing in amounts of external fat, LVS can be used to predict cutability not only in terms of lean meat yield, but also in predicting carcass fat percentages.

Table 3 presents coefficients of determination and root mean square error values for regression models developed to predict boneless and bone-in lean meat and subprimal yields for lamb carcass sides using the best-fit equations of LVS output and hot carcass weight (Table 2), whole number expert USDA Yield Grades, expert Yield Grades computed to the tenth of a grade unit, and on-line USDA whole-number Yield Grades. A greater proportion of variation in boneless saleable meat yield and boneless subprimal yield was explained with greater precision using the LVS best-fit regression equations compared to that variation explained by whole number expert USDA Yield Grades, expert Yield Grades computed to the tenth of a grade unit, or on-line USDA whole-number Yield Grades.

Bone-in saleable meat and subprimal yields also were predicted with more accuracy and precision using the LVS best-fit regression models than with the whole number expert USDA Yield Grades and on-line USDA whole-number Yield Grades regression equations. Therefore, use of LVS in a commercial setting was capable of more accurately assessing carcass yields, in terms of the bone-in cuts that are typical of many of today's breaking operations, than use of whole number expert USDA Yield Grades or on-line USDA whole-number Yield Grades.

Regression models to predict weight of wholesale cuts yielded from the four primals of lamb carcasses (as opposed to percentage yields) were developed (Table 4). It is important to note that for all models presented in Table 4, the high accuracy with which these regression models were able to predict pounds of wholesale cuts yielded from lamb carcasses was likely attributable to the inclusion of hot carcass weight, which is an input in the LVS system, in the models. As reported earlier, hot carcass weight used in prediction models in this study was supported by Garrett et al. (1992) who reported that carcass weight is highly correlated to yield, and thus, an important factor to be included in lamb carcass cutability prediction models.

Previous studies evaluating the use of video image analysis instrumentation in the beef industry to predict carcass yields have suggested that this technology can be used, in combination with USDA yield grade factors, to predict red meat yield (Belk et al., 1998; Cannell et al., 1999; Steiner et al., 2000). Table 5 presents coefficients of determination and root mean square error values for regression models that included LVS output variables, HCW, and carcass measurements provided by expert graders (adjusted PYG and REA) to predict lean meat and subprimal percentage yields from lamb carcasses. Ribeye area measurements were obtained on 124 of the carcasses included in the study; thus, the prediction models presented in Table 5 were developed only from data acquired from those 124 carcasses to determine if the addition of adjusted PYG and REA to LVS output variables would explain a greater proportion of the observed variability. The inclusion of the two additional carcass measures contributed a predictive improvement of 3% and 9% of the variability, respectively, as well as an improvement in precision, explained in boneless and bone-in saleable meat yield versus the best-fit model (Table 2) that included only LVS output variables and HCW. The models in Table 5 suggest that while the models in Table 2 clearly exceeded the prediction accuracy and precision of whole number expert USDA Yield Grades, expert Yield Grades calculated to the tenth of a unit, and on-line whole number USDA Yield Grades in the prediction of carcass yields, by adding expert adjusted PYG and REA to the independent variables of LVS output and HCW in the model, further enhancement of the predictive ability is achieved.

IMPLICATIONS

The on-line Lamb Vision System explained a greater proportion of variation in carcass yields, with typically greater precision than did whole number expert USDA Yield Grades, expert USDA Yield Grades calculated to the tenth, and on-line USDA Yield Grades.

In addition to predicting fabrication yields of lamb carcass sides accurately, this study indicated that LVS can be used to predict fabricated cut weights from lamb carcasses accurately.

The predictive ability of the Lamb Vision System can be enhanced by adding grader-determined measures from carcasses (REA, adjusted PYG) to prediction models.

These results suggested that the Lamb Vision System can be used in a commercial setting to sort lamb carcasses accurately based on cutability. In addition, a value-based pricing system should be developed to assign, more accurately, true carcass value to lamb carcasses.

LITERATURE CITED

Beerman, D.H., T.F. Robinson, and D.E. Hogue. 1995. Impact of Composition Manipulation on Lean Lamb Production in the United States. J.Anim.Sci. 73:2493-2502

Belk, K.E., J.A. Scanga, J.D. Tatum, J.W. Wise, and G.C. Smith. 1998. Simulated instrument augmentation of USDA Yield Grade application to beef carcasses. J.Anim.Sci. 76:522-527

Cannell, R.C., J.D. Tatum, K.E. Belk, and G.C. Smith. 1998. An evaluation of Dual-Component Video Image Analysis System (VIASCAN^{TM}) as a predictor of beef carcass red meat yield percentage for augmenting application of USDA Quality and Yield Grades, and as an on-line testing device for use in sorting beef carcasses according to tenderness and palatability. Final Research Report to NCBA, Englewood, CO. Colorado State University, Fort Collins, CO

Garrett, R.P., J.W. Savell, H.R. Cross, and H.K. Johnson. 1992. Yield Grade and carcass weight effects on the cutability of lamb carcasses fabricated into innovative style subprimals. J.Anim.Sci. 70:1829-1839

Heaton, K.L., J.B. Morgan, J.D. Tatum, J.W. Wise, R.P. Garrett, H.G. Dolezal, H.D. Loveday, and G.C. Smith. 1993. Field studies to document efficacy of visual assignments of lamb carcasses to appropriate USDA Yield Grades. Sheep Research Journal. 9:7-15.

NAMP. 1997. The Meat Buyers Guide. North American Meat Processors Association, Reston, VA.

Steiner, R., A.M. Wyle, D.J. Vote, D.L. Roeber, R.C. Cannell, R.J. Richmond, K. Markey, J.W. Wise, M.E. O’Conner, R.R. Jones, K.E. Belk, J.D. Tatum, and G.C. Smith. 2000. Real time augmentation of USDA Yield Grade application to beef carcasses using state-of-the-art VIA instrumentation. Final Report to NCBA, Englewood, CO. Colorado State University, Fort Collins, CO.

Tatum, J.D., J.W. Savell, H.R. Cross, and J.G. Butler. 1989. A national survey of lamb carcass cutability traits. SID Res. J. 5(1):23

Table 1. Coefficients of determination (R^2) and root mean square error (RMSE) terms for regression equations using Expert USDA Yield Grade to the whole number, Expert USDA Yield Grade to the tenth of a Yield Grade unit, and On-line USDA Yield Grade for the prediction of fabrication yields from lamb carcass sides.

	Boneless Side			Bone-In Side		
	R^2	RMSE	Variables in Model	R^2	RMSE	Variables in Model
Expert Grader (Whole Grade):						
Saleable meat yield[a]	0.523	0.032	Expert YG	0.566	0.022	Expert YG
Subprimal yield[b]	0.499	0.025	Expert YG	0.522	0.021	Expert YG
Fat yield[c]	0.668	0.036	Expert YG	0.650	0.028	Expert YG
Lean trim yield[d]	0.243	0.014	Expert YG	0.032	0.010	Expert YG
Bone yield[e]	0.525	0.016	Expert YG	0.292	0.014	Expert YG
Expert Grader (Tenth Grade):						
Saleable meat yield[a]	0.575	0.030	Expert YG	0.623	0.021	Expert YG
Subprimal yield[b]	0.560	0.024	Expert YG	0.566	0.020	Expert YG
Fat yield[c]	0.734	0.032	Expert YG	0.710	0.025	Expert YG
Lean trim yield[d]	0.249	0.014	Expert YG	0.041	0.010	Expert YG
Bone yield[e]	0.578	0.015	Expert YG	0.314	0.013	Expert YG
On-line Grader (Whole Grade):						
Saleable meat yield[a]	0.525	0.032	Line YG	0.562	0.022	Line YG
Subprimal yield[b]	0.508	0.025	Line YG	0.533	0.021	Line YG
Fat yield[c]	0.660	0.036	Line YG	0.618	0.029	Line YG
Lean trim yield[d]	0.239	0.014	Line YG	0.024	0.010	Line YG
Bone yield[e]	0.506	0.017	Line YG	0.230	0.014	Line YG

[a] Saleable meat yield: subprimal cuts and lean trim from the leg, loin, rack, shoulder, and thin cuts as a percentage of carcass side weight;

[b] Subprimal yield: subprimal cuts only from the leg, loin, rack, and shoulder as a percentage of carcass side weight;

[c] Fat yield: percentage of cold side weight of trimmable fat from the production of wholesale cuts;

[d] Lean trim yield: percentage of cold side weight of lean trim from the production of wholesale cuts.;

[e] Bone yield: percentage of cold side weight of bones removed during production of wholesale cuts.

Table 2. Coefficients of determination (R^2) and root mean square error (RMSE) values for best-fit regression equations developed to predict percent carcass side yields using Lamb Vision System output plus HCW.

	Boneless Side			Bone-In Side		
	R^2	RMSE	Variables in Model[f]	R^2	RMSE	Variables in Model[f]
Saleable meat yield[a]	.631	.028	HCW, CxsLength, TaPC2, GrRtLeg, LwPC2, LWPC3, ShRi	.623	.021	HCW, CxsLength, GrRt Leg, ShBi, LegGap, GrAngPC1
Subprimal yield[b]	.610	.023	HCW, CxsLength, GrRtLeg, TaPC2, LnRi, GrAngPC1	.570	.020	HCW, CxsLength, GrRtLeg, TaPC2, ShBi, GrAngPC1
Fat yield[c]	.766	.030	HCW, TaPc2, CxsLength, GrRtLeg, LwPC3, GrAngPC2, LwPC2, ShRi	.746	.024	HCW, CxsLength, LegGap, TwPC1, TaPC2, GrAngPC1, ShRi
Lean trim yield[d]	.310	.014	HCW, GrLftLeg, GrRtLeg, TwPC2, TaPC2, ShRi	.119	.009	LwPC2, LwPC3, LnBi
Bone yield[e]	.631	.015	HCW, TaPC2, CxsLength, GrLftLeg, TwPC2, LwPC3, GrAngPC2, LnRi	.450	.012	TaPC2, TwPC2, LwPC3, LwPC2

[a] Saleable meat yield: subprimal cuts and lean trim from the leg, loin, rack, shoulder, and thin cuts as a percentage of carcass side weight;

[b] Subprimal yield: subprimal cuts from the leg, loin, rack, and shoulder as a percentage of carcass side weight.;

[c] Fat yield: percentage of cold side weight of fat from the production of wholesale cuts.;

[d] Lean trim yield: percentage of cold side weight of lean trim from the production of wholesale cuts.;

[e] Bone yield: percentage of cold side weight of bones removed during production of wholesale cuts.

[f] Variables in model: HCW = Hot Carcass Weight, CxsLength = Carcass Length, TaPC2 = Principle Component Variable 2 for Total Area, TwPC1 = Principle Component 1 for Total Width, TwPC2 = Principle Component 2 for Total Width, GrRtLeg = Groin to Right Leg length, GrLftLeg = Groin to Left Leg length, LwPC2 = Principle Component Variable 2 for Leg Width, LwPC3 = Principle Component Variable 3 for Leg Width, ShRi = Red Color score for shoulder (adjusted for intensity), ShBi = Blue Color score for shoulder (adjusted for intensity), LnRi = Red Color score for loin (adjusted for intensity), LnBi = Blue Color score for loin (adjusted for intensity), GrAngPC1 = Principle Component 1 for Groin Angle, GrAngPC2 = Principle Component 2 for Groin Angle, LegGap = distance between the two legs.

Table 3. Coefficients of Determination (R^2) for whole number USDA Expert Yield Grades, Expert Yield Grades calculated to the tenth of a grade unit, On-line Yield Grades, and Lamb Vision System best-fit equations for the prediction of saleable meat yield[a] and subprimal yield[b].

	Boneless Side		Bone-in Side	
	R^2	RMSE	R^2	RMSE
Saleable Meat Yield:				
Lamb Vision System (best-fit equation)	.631	.028	.623	.021
Expert USDA Yield Grade to the Whole Number	.523	.032	.566	.022
Expert USDA Yield Grade to the Tenth	.575	.030	.623	.021
USDA Line Grade	.525	.032	.562	.022
Subprimal Yield:				
Lamb Vision System (best-fit equation)	.610	.023	.570	.020
Expert USDA Yield Grade to the Whole Number	.499	.025	.522	.021
Expert USDA Yield Grade to the Tenth	.560	.024	.566	.020
USDA Line Grade	.508	.025	.533	.021

[a] Saleable meat yield: subprimal cuts and lean trim from the leg, loin, rack, shoulder, and thin cuts as a percentage of carcass side weight.

[b] Subprimal yield: subprimal cuts from the leg, loin, rack, and shoulder as a percentage of carcass side weight.

Table 4. Coefficients of determination (R^2) and root mean square error (RMSE) values for regression equations using Lamb Vision System output variables and HCW to predict the weight of wholesale cuts yielded from lamb carcasses.

Primal Cut	Boneless Side			Bone-In Side		
	R^2	RMSE	Variables in Model[a]	R^2	RMSE	Variables in Model[a]
Shoulder	.765	.482	HCW, TwPC1	.840	.518	HCW, CxsLength, LnBi
Rack	.652	.089	HCW, ShRi, TaPC2	.716	.351	HCW, TaPC1
Loin	.669	.135	HCW, TwPC2, CxsLength, LnRi	.723	.206	HCW, CxsLength, TwPC1
Leg	.858	.397	HCW, TaPC1, LwPC3, GrAngPC2, TwPC1	.853	.471	HCW, CxsLength, TwPC2, GrAngPC2

[a] Variables in model: HCW = Hot Carcass Weight, CxsLength = Carcass Length, TaPC2 = Principle Component Variable 2 for Total Area, TwPC1 = Principle Component 1 for Total Width, TwPC2 = Principle Component 2 for Total Width, LwPC3 = Principle Component Variable 3 for Leg Width, ShRi = Red Color score for shoulder (adjusted for intensity), LnBi = Blue Color score for loin (adjusted for intensity), GrAngPC2 = Principle Component 2 for Groin Angle.

Table 5. Coefficients of determination (R^2) and root mean square error (RMSE) values for regression equations using Lamb Vision System factors, HCW, and REA and/or adjusted PYG measurements provided by expert graders, to predict saleable meat[a] and subprimal[b] yields from lamb carcass sides (N = 124).

	Boneless Side			Bone-In Side		
	R^2	RMSE	Variables in Model[c]	R^2	RMSE	Variables in Model[c]
Lamb Vision System variables, HCW, adj. PYG, and REA*:*						
Saleable Meat Yield	.707	.030	HCW, CxsLength, GrRtLeg, TaPC2, LwPC2, LwPC3, ShRi, ADJ FT, REA	.809	.017	HCW, CxsLength, GrRtLeg, TaPC2, LegGap, GrAngPC1, ShBi, ADJ FT, REA
Subprimal Yield	.705	.023	HCW, CxsLength, GrRtLeg, TaPC2, GrAngPC1, LnRi, ADJ FT, REA	.765	.017	HCW, CxsLength, GrRtLeg, TaPC2, GrAngPC1, ShBi, ADJ FT, REA

[a] Saleable meat yield: subprimal cuts and lean trim from the leg, loin, rack, shoulder, and thin cuts as a percentage of carcass side weight.

[b] Subprimal yield: subprimal cuts from the leg, loin, rack, and shoulder as a percentage of carcass side weight.

[c] Variables in model: HCW = Hot Carcass Weight, CxsLength = Carcass Length, TaPC2 = Principle Component Variable 2 for Total Area, GrRtLeg = Groin to Right Leg length, GrLftLeg = Groin to Left Leg length, LwPC2 = Principle Component Variable 2 for Leg Width, LwPC3 = Principle Component Variable 3 for Leg Width, ShRi = Red Color score for shoulder (adjusted for intensity), ShBi = Blue Color score for shoulder adjusted for intensity, LnRi = Red Color score for loin adjusted for intensity, GrAngPC1 = Principle Component 1 for Groin Angle, LegGap = distance between the two legs, REA = Ribeye area, ADJ FT = adjusted fat thickness (taken between the 12th and 13th ribs)