Evaluation of Ultrasound for Prediction of Carcass Meat Yield and Meat Quality in Korean Native Cattle (Hanwoo)**

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ABSTRACT : Three hundred thirty five progeny testing steers of Korean beef cattle were evaluated ultrasonically for back fat thickness (BFT), longissimus muscle area (LMA) and intramuscular fat (IF) before slaughter. Class measurements associated with the Korean yield grade and quality grade were also obtained. Residual standard deviation between ultrasonic estimates and carcass measurements of BFT, LMA were 1.49 mm and 0.96 cm^2. The linear correlation coefficients ($p<0.01$) between ultrasonic estimates and carcass measurements of BFT, LMA and IF were 0.75, 0.57 and 0.67, respectively. Results for improving predictions of yield grade by four methods-the Korean yield grade index equation, fat depth alone, regression and decision tree methods were 75.4%, 79.6%, 64.3% and 81.4%, respectively. We conclude that the decision tree method can easily predict yield grade and is also useful for increasing prediction accuracy rate. *(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 4 : 591-595)*

Key Words : Ultrasound, Korean Native Cattle, Meat Yield, Meat Quality, Data Mining, Decision Trees

INTRODUCTION

Real-time ultrasound instruments have been widely used in the field for estimating live animal BFT, LMA and IF (Perkins et al., 1992; Robinson et al., 1992). Recently, several institutions and organizations have developed software systems, that can predict percentage of intramuscular fat or marbling from real time ultrasound images. However, limited information has been published on the accuracy or precision of these systems (Brethour, 1994; Herring et al., 1998). Since 1988, the Japanese Meat Grading Association has provided a beef grading system for quantifying meat yield and quality factors by subjective evaluation (Ozutsumi et al., 1996). The ability to use ultrasound to precisely and accurately estimate carcass measurements in live animals should be of benefit to the beef industry, allowing it to move away from the current practice of pricing cattle on pen averages to a value-based marketing system. Smith et al. (1992) found that correlation coefficients between live animal ultrasonic and carcass measurements of BFT and LMA varied from 0.81 to 0.82 and from 0.43 to 0.63, respectively. Ultrasonic speckle deposits were related to the degree of marbling. Skilled sonographers can visually interpret an echogram and estimate marbling in a live animal with fair accuracy.

The objective of this study was to compare and evaluate ultrasonic measurements of BFT, LMA and IF before slaughter for improving prediction of yield grade and marbling score. In this study, scanning data were evaluated for increasing prediction accuracy rate by the yield grade index, fat depth alone, regression and decision tree methods.

MATERIALS AND METHODS

Three hundred thirty five progeny testing Hanwoo (Korean native cattle) steers were ultrasonically scanned by Super-eye Meat (FHK Co. Ltd., Japan) with the electric linear probe (2 MHz frequency; 27×147 mm) between the 13th rib and lumbar vertebrae on the left side nearly one week before slaughter for estimating BFT, LMA and IF. Scanned images were obtained using double frame display capabilities of the equipment, and a transducer guide was used to minimize error that might occur due to animal back line curvature and the overlapping step required to produce one complete image of the longissimus muscle. The resulting ultrasound images were recorded on MO diskette and later viewed on a display monitor to estimate both ultrasound BFT and ultrasound LMA. Internal machine calipers of known length relative to the scanned image were used to draw a line that was then measured on the screen. Carcass fat thickness was measured at two-thirds the length of the longissimus muscle from the chine bone end, and longissimus muscle area was measured at the 13th rib end. A complete image was obtained by hard copy to estimate marbling score; another image recorded on videotape was viewed to estimate both BFT and LMA using computer software (SCD-150F, FHK, Japan).

In this study, ultrasonic estimate was compared to carcass value for increased prediction accuracy by four prediction methods: yield grade index, fat depth alone, regression and decision tree. The yield grade index (YGI)

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equation used in Korea is 65.834-(0.393×BFT)+(0.088× LMA)-(0.008×carcass weight, CWT)+2.01(summing point of Hanwoo only). In the official Korean grade standards, yield grade index above 69 is yield grade A, yield grade index below 69 and above 66 is yield grade B and yield grade index below 66 is yield grade C, respectively. However, CWT was assumed to be 60% of live weight by ultrasonic YGI. The fat depth alone method used only FDA measurements independently of YGI. Simple and multiple-regression techniques (SAS, Ver. 8.01; 2000) were used to evaluate the best-fit equation to explain variation in retail yield components (BFT, LMA and LWT) from ultrasonic estimates. The decision trees is a tool used in data mining, the process of selecting, exploring and modeling large amounts of data to uncover previously unknown patterns. An empirical decision trees represents a segmentation of the data that is created by applying a series of simple rules. Each rule assigns an observation to a segment based on the value of one input. One rule is applied after another, resulting in a hierarchy of segments within segments. The hierarchy is called a tree, and each segment is called a node. The original segment contains the entire data set and is called the root node of the tree. A node with all its successors forms a branch of the node that created it. The final nodes are called leaves. For each leaf, a decision is made and applied to all observations in the leaf (SAS Institute Inc. 1997). The analysis of decision trees determines the splitting criterion and stopping rule to obtain the decision tree as the analysis purpose and the data structure, removes the branches that has high risk of classification fallacious and rule inappropriate induction rule, and interprets the analysis results after the validation evaluation.

First of all, the splitting criterion means the standard that becomes the choice of forecasting variable and joining the criterion when child node forms from the parent node. The splitting criterion is changed if the target variable is categorical or continuous variable. The target variable is considered as categorical variable for the analytical purpose in this study. When the target variable is categorical variable, the splitting criterion uses chi-square statistic. Namely, the p-value of the chi-square statistic was obtained, and then the child node can be formed by the forecasting variable that has the least p-value and the optimal splitting of that time. The chi-square statistic can be calculated by r×c splitting table that is consisted with observing frequency. The Pearson's chi-square statistic is defined as by the

$$\chi^2 = \sum_{i,j} \frac{(f_{ij} - e_{ij})^2}{e_{ij}}$$

splitting table. Where, the e_{ij} means expected frequency calculated under the hypothesis of identical distribution or independent distribution. It is calculated as follow.

$$e_{ij} = \frac{f_{i.} \times f_{.j}}{f}$$

$f_{i.}$: summation of ith row, $f_{.j}$: summation of jth row, $f_{..}$: total summation

Second, the stopping rule means several rules that do not occur the further splitting and make the present node becoming the terminal node. The multi-node method that is formed from parent node and has maximum node, 3 child nodes, was used in the study (Choi et al., 1999).

The decision trees that have too many nodes has a probability that has large forecasting error when it is applied for new data. Thus, inappropriate branch should be removed from decision tree formed, and the decision tree that has sub-tree structure was decided as final forecasting model. The SAS E-miner 3.0 program (2000) was applied in this study.

Means, standard deviations and regression analyses were calculated for carcass and ultrasound measures.

RESULTS AND DISCUSSION.

Carcass measures were available 224 carcasses with Korean yield grade A, 109 carcasses with yield grade B and only 2 carcasses with yield grade C. We used 333 carcasses for analysis, excluding the 2 heads of yield grade C because of the small number. Formula means and standard deviations for castrated Hanwoo traits of BFT and LMA are presented in table 1. In this study, mean of BFT and LMA estimates were 6.44 mm and 72.44 cm^2; however, ultrasonic estimates were 5.84 mm and 68.33 cm^2, respectively. Residual standard deviations between carcass BFT-ultrasonic BFT and carcass LMA-ultrasonic LMA were 1.34 and 0.84 for yield grade A and 1.53 and 0.97 for yield grade B, respectively. This could explain increased errors of

Table 1. Means and standard deviations between ultrasonic and carcass measures by yield grade index of Korean beef cattle (Hanwoo)

YGC[1]	BFC[2] (mm)	BFU[3] (mm)	LMAC[4] (cm^2)	LMAU[5] (cm^2)	STD BFC-BFU	STD LMAC-LMAU
A	5.32	5.08	73.80	68.30	1.34	0.84
B	8.75	7.42	69.66	68.41	1.53	0.97
Total	6.44	5.84	72.44	68.33	1.49	0.96

[1] Carcass yield grade, [2] Carcass back fat, [3] Ultrasonic back fat, [4] Carcass Longissimus muscle area.
[5] Ultrasonic Longissimus muscle area.

prediction for yield grade B rather than yield grade A. These compositional differences may account for the prediction differences.

In Smith et al. (1990), cattle with LMA>104 cm^2 generally were underestimated, whereas cattle with LMA<84.5 cm^2 generally were overestimated. Waldner et al. (1992) reported that LMA was underestimated in bulls with less than approximately 70 cm^2 of LMA, whereas LMA was overestimated in bulls with greater than approximately 85 cm^2 of LMA. In general, Kreider et al. (1986) found LMA to be overestimated, whereas McMillin et al. (1987) found LMA to be underestimated by ultrasonic methods.

Table 2 presents correlations between predicted (BFTU, LMAU) and observed carcass measurements (BFTC, LMAC). Significant relationships ($p<0.01$) were found 0.75, between BFTU and BFTC; 0.57, LMAU and LMAC; and 0.57, ultrasonic marbling score (MSU) and carcass marbling score (MSC). Fat thickness has the largest influence on yield grade (YG) of any of the factors involved in the YG equation (Abraham et al., 1980). Correlation coefficients between BFTU and BFTC and explain were 0.86 and 0.85. Correlation coefficients between LMAU and LMAC have been reported (Miller et al., 1986; Recio et al., 1986; Parrett et al., 1987; Smith et al., 1990; McLaren et al., 1991). These correlations were large and positive. Figure 1 presents the relationship between YG and BFT. In appearance of cattle carcasses, yield grade A included 95.4% of carcasses with less than 6 mm of BFT and yield grade B was 91.0% at greater than 8 mm of BFT. In ultrasonic measurements, yield grade A was 85.4% at less than 5 mm and yield grade B was 71.4% at larger than 9 mm.

Analysis of technician proficiency data for certification of real time ultrasonic operators revealed that LMA generally was overestimated and fat was underestimated by ultrasonic estimates. The decision tree method employed live weight, BFTU and LMAU as target parameters, and used input parameters for satisfied target parameter. According to this result, 92.4% of carcasses with less than 5 mm BFTU and with greater than 40 cm^2 LMAU were allocated to yield grade A, and 62.5% of carcasses with 6 to 7 mm BFTU and less than 66 cm^2 LMAU was yield grade B. However, 74.6% within 66 cm^2 LMAU was yield grade A, and 77.4% within 8 mm BFTU was yield grade B.

Table 3 presents a comparison of the four methods used to analyze prediction accuracy between ultrasonic and carcass measurements. Firstly, prediction accuracy of the yield grade index was 77.7% at yield grade A and 70.6% at yield grade B. The fat depth alone method predicted 84.4% of carcasses less than 5 mm at grade A, and 69.7% of carcasses more than 9 mm at grade B. The regression method used YGI=70.69***-0.00239*** BW-0.34787***

Table 2. Correlation coefficient between ultrasonic and carcass measures

	Live weight	BFU	LMAU	MSU	Carcass weight	BFC	LMAC	MSC	YGI
LW	1.00								
BFU	0.33***	1.00							
LMAU	0.44***	0.28***	1.00						
MSU	-0.21***	-0.12*	-0.18***	1.00					
CW	0.92***	0.38***	0.50***	-0.25***	1.00				
BFC	0.34***	0.75***	0.26***	-0.13*	0.38***	1.00			
LMAC	0.45***	0.16**	0.57***	-0.21***	0.57***	0.12*	1.00		
MSC	-0.26***	-0.15**	-0.19***	0.67***	-0.30***	-0.20***	-0.22***	1.00	
YGI	-0.22***	-0.61***	0.02	0.04	-0.21***	-0.84***	0.40***	0.10	1.00

*** $p<0.001$, ** $p<-0.01$, * $p<-0.05$.

Table 3. Comparison of prediction accuracy by four methods on yield grade

YGIC	YGIU	Formula		Fat depth alone		Regression		Decision tree	
		N[1)]	Accuracy	N	Accuracy	N	Accuracy	N	Accuracy
A	A	174[2)]	77.7%[3)]	189	84.4%	201	89.7%	192	85.7%
	B	50		35		23		32	
Subtotal		224[4)]		224		224		224	
B	A	32		33		96		30	
	B	77[5)]	70.6%	76	69.7%	13	11.9%	79	72.5%
Subtotal		109		109		109		109	
Total		333[6)]	75.4%[7)]	333	79.6%	333	64.3%	333	81.4%

[1)] Number of carcasses. [3)] 2)/4)×100. [7)] [2)+5)]/6)×100.

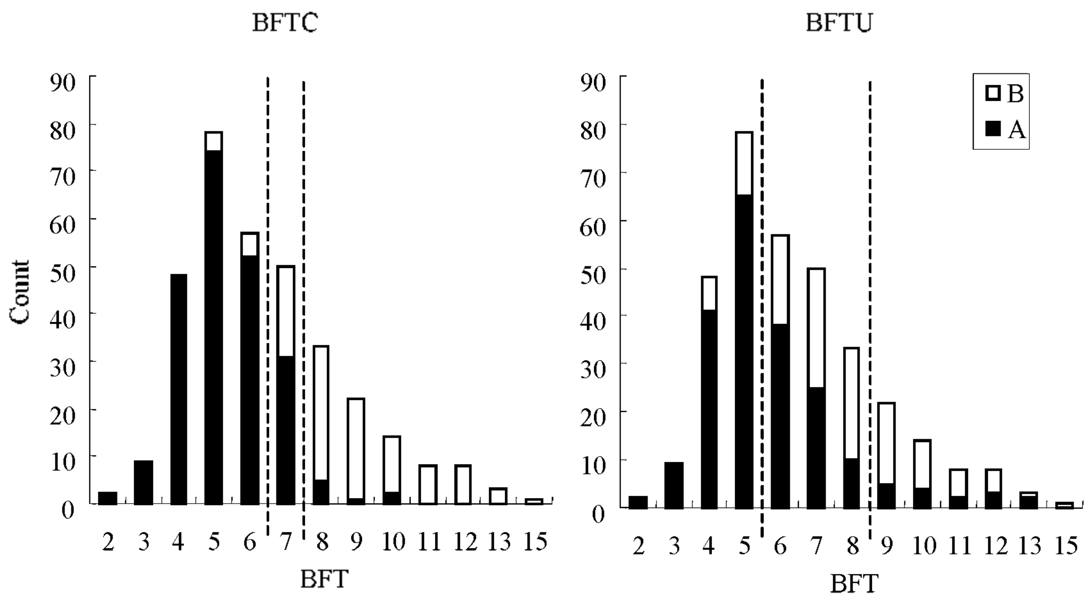

Figure 1. Frequency distributions between BFTU, BFTC and YG

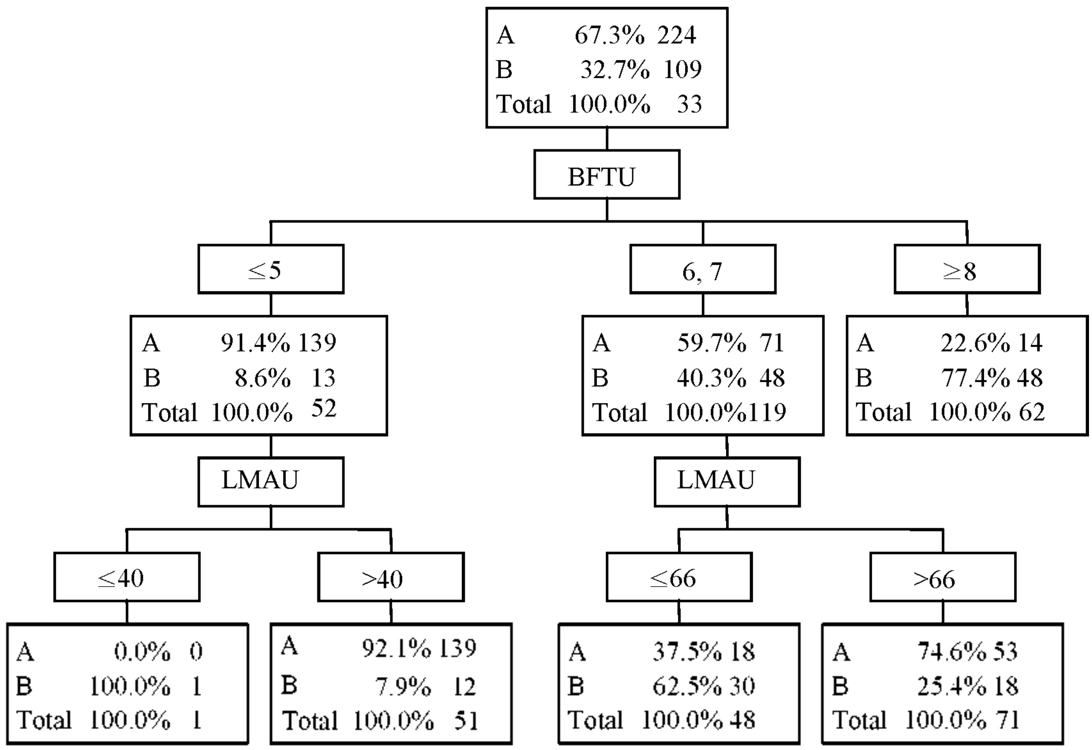

Figure 2. Distribution pattern of yield grade index by the decision tree method

BFTU+0.02808***LMAU (*** $p<0.001$). In this method prediction accuracy rate increased 12% at grade A, but decreased 58.7% at grade B. Finally, prediction accuracy by the decision tree method was 85.7% at grade A and, 72.5% at grade B.

The prediction accuracy of quality grade according to four Korean grade levels is presented in table 4. Meat quality level prediction accuracy was 67.3% at the third grade, 63.7% at second, 62.9% at first and 47.4% at prime.

These results suggest that the decision tree method showed best accuracy among the four methods. Also, if live weight is unknown (as on the small-scale farm), the

Table 4. Prediction accuracy between carcasses marbling score and ultrasonic marbling score measurements

MSC	MSU				Total	Accuracy
	0	1	2	3		
0	9[1)]	9	1		19	47.4%
1	7	61[2)]	23	6	97	62.9%
2		19	107[3)]	42	168	63.7%
3		2	14	33[4)]	49	67.3%
Total	16	91	145	81	333[5)]	63.1%[6)]

[6)] [1)+2)+3)+4)]/5)×100.

decision tree method enables prediction using only ultrasonic measurements (BFT and LMA). As we collect more data, prediction accuracy will increase giving satisfactory results.

Placement of the transducer for near and far gain image registration, and interpretation of the image produced by the technician may cause error between ultrasound and actual carcass measurements of BFT and LMA. Better control of focusing and signal preprocessing along with higher gray-level resolution and the ability to transfer digital data directly from the ultrasound scan converter into computer processing should enhance the accuracy of ultrasound prediction.

CONCLUSIONS

The results of the present study show that the decision trees method for meat yield grade predicted at 81.4% accuracy. Also, scanned images for meat quality grade predicted 63.1% accuracy. Ultrasonic measurements made before slaughter are useful for estimating carcass BFT, LMA, and IF. An improved system is needed for accurate and rapid measurements of yield grade and quality grade in live cattle.

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