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Prediction of carcass composition and individual carcass cuts of Japanese Black steers

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ABSTRACT

The objective of this study was to develop equations to predict carcass tissue weights and percentages and boneless carcass non-trimmed cut weights by using the cold carcass weight (CCW) and three other traits at the 6–7th rib section, which are routinely collected in carcass markets in Japan. Carcasses from 94 Japanese Black steers were used for the multiple regression analysis with a stepwise procedure and a novel Least Absolute Shrinkage and Selection Operator (LASSO). The accuracies of prediction (R^2) and RMSEs for the carcass tissue and cut weights were similar between the two procedures. In contrast, LASSO appeared to be the better procedure for predicting carcass tissue percentages. The longissimus muscle area and subcutaneous fat thickness were the important predictors for the lean percentage in the stepwise procedure, and CCW was additionally selected when the LASSO procedure was used.

1. Introduction

In the beef industry, carcass composition determines the value of carcasses. Optimum fat levels and a higher proportion of lean to bone are regarded as qualities of a superior carcass (Berg, Andersen, & Liboriussen, 1978). Therefore, the prediction of carcass composition is important for carcass evaluation and the evaluation of feeding experiments for meat production systems (Karnuah et al., 2001). Although the most accurate method for estimating carcass composition is physical separation of the carcass into lean, fat and bone, this technique is too time-consuming and expensive to be practical for commercial application and research purposes.

In Japan, all possible efforts have been made to produce highly marbled beef because of the higher price it commands in the carcass markets and in butcher shops or grocery stores. Thus the Japanese Black (JB) cattle breed has been subjected to numerous genetic refinements and is fed high-energy concentrates through intensive feeding systems. The result is a highly marbled beef with a superior intramuscular fat deposition compared to all other breeds worldwide (Xie et al., 1996). Although there have been many studies on prediction of the carcass composition of JB steers using carcass cross-sectional measurements, morphometric measurements and various electronic devices (Karnuah et al., 2001; Zembayashi, 1999), these methods are too time-consuming and expensive for commercial application.

A carcass evaluation technique based on carcass cuts has been developed as an alternative to physical separation of the carcass into lean, fat and bone. Carcass studies based on such part carcass data (carcass cuts) have a clear research advantage because these data are relatively easily obtained (Johnson & Charles, 1981). The retail selling prices for JB cattle differ considerably among the different carcass cuts, from US$4.97/100 g for brisket to US$11.57/100 g for tender-loin (JMI, 2010). Mukai, Sadahira, and Yoshimura (2004) have reported that higher-priced retail cuts were greater in JB than Holstein cattle. Thus, accurate prediction of higher-priced cuts would be economically desirable for JB cattle.

In Japan, the quality of beef carcasses has been mainly judged based on the carcass weight and three other carcass traits (the longissimus muscle area, rib thickness and subcutaneous fat thickness) at the 6th–7th rib section (JMGA, 1988), because these traits are relatively easy to measure and routinely collected in the carcass markets. Thus, if equations could be developed for predicting carcass composition and individual carcass cut weights by using the data on such carcass traits, they would be valuable as a simple and practical carcass evaluation technique.

For many years, multiple regression analysis with a stepwise procedure has been the most popular procedure for predicting carcass composition in animal science. In recent years, however, many statisticians have cautioned against the use of a stepwise procedure and have described the numerous pitfalls of such an approach (Harrell, 2001; Mundry & Nunn, 2009). These arguments may lead to a shift from the popular stepwise procedure to other novel procedure used in multiple regression analysis. Cadavez and Henningsen (2012) predicted the

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carcass composition of lambs using seemingly unrelated regression. Pabiou et al. (2011) predict various wholesale carcass cuts using novel procedures such as the partial least square regression and least absolute shrinkage and selection operator (LASSO; Tibshirani, 1996).

The objective of this study was to develop equations to estimate carcass tissue weights, the percentages of the carcass tissue and the boneless carcass non-trimmed cut weights based on the carcass traits for JB steers using traditional (stepwise) and novel regression procedures (LASSO).

2. Materials and methods

2.1. Data collection

The carcass data used in this study were collected from JB steers (n = 94) fattened and slaughtered from 1988 to 1996 at the Chugoku National Agricultural Experiment Station, the Ministry of Agriculture, Forestry and Fisheries, Japan. The ages of the steers at slaughter ranged from 18 to 36 months. The actual weights of lean, fat and bone were measured following the physical dissection of the left side of the carcass using the protocol of Butterfield (1963).

The left sides of the carcasses were normally divided into 13 retail cuts according to the processing manual for retail cut trading (JMGA, 1989). In addition, in this study, the shank was further divided into two parts, the shin of the forelimb and the shank of the hindlimb. The individual carcass cuts obtained were the neck, shoulder-clod, shoulder-chuck-roll, brisket, tender-loin, rib-chuck-roll, short-plate-brisket, strip-loin, top-round, knuckle, sirloin-butt, outside-round, shin and shank. The chuck-roll was divided into two parts as the shoulder- and rib-chuck-roll, respectively (Fig. 1). The kidney, perirenal fat and the offal around the pelvis were included in the carcass (included in carcass weight) but excluded from the calculation of carcass tissues (excluded from fat weight). It should be noted that fat was not trimmed from the carcass cuts in this study and thus the sums of the lean and fat weights of the individual carcass cuts were nearly equal to the lean and fat weights for the entire carcass (i.e., the carcass cuts in this study were boneless non-trimmed cuts but not retail cuts like those sold in butcher shops or grocery stores). The commercial carcass cuts were not available because the original objective of the project was to investigate the carcass composition of JB cattle in experimental stations.

In Japanese carcass markets, the carcass measurements and yield score determination have been carried out on the left side of the carcass between the 6th and 7th rib sections (JMGA, 1988; Strong, 2004). The longissimus muscle area (rib eye area), rib thickness and subcutaneous fat thickness are usually measured as carcass traits. The longissimus muscle area was measured by grid approximation by placing a transparent sheet, with a 1 cm × 1 cm on a section and counting the number of intersections. The rib thickness was the distance between the latissimus muscle and pleura membrane measured at the mid-point of rib ends (Fig. 2).

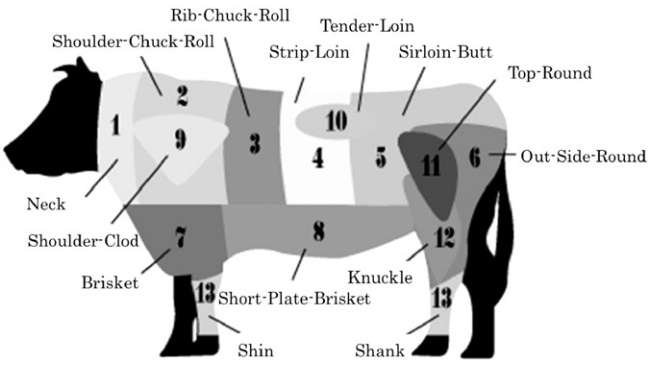

Fig. 1. Individual carcass cuts.

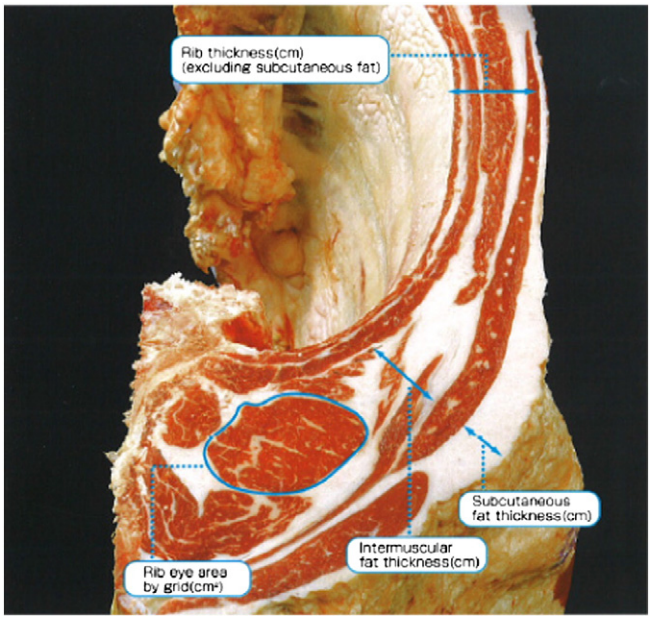

Fig. 2. Carcass measurement on the 6th to 7th rib section from JMGA (2000).

2.2. Statistical analyses

In this study, a traditional and a novel procedure were used for multiple regression analysis. The stepwise procedure of the maximum R^2 (coefficient of determination) was used as a traditional procedure for the multiple linear regression analysis. Only predictors that were significant at $P < 0.05$ were selected for development of the prediction equations. On the other hand, LASSO (Tibshirani, 1996) was used as a novel procedure; this method was developed as a constrained form of the ordinary least squares method in which the sum of the absolute values of the regression coefficients is constrained to be smaller than a specified parameter. In this procedure, shrinkage and variable selection are achieved simultaneously because the parameter estimates are often shrunk to exactly zero (Dahlgren, 2010). The k-fold (k = 5) cross validation with the residual sum of squares was used as a criterion in the model selection. The same procedure was adopted to predict meat yield in lamb carcasses by Siddell, McLeod, Toohey, van de Ven, and Hopkins (2012). All analyses were conducted using the GLMSELECT procedure of SAS Institute, Inc. (2008).

To predict the carcass composition, entire carcass tissue weights and individual carcass cut weights as dependent variables, the predictors (i.e., independent variables) used were the cold carcass weight (CCW, kg), longissimus muscle area (LMA, cm^2), rib thickness (RT, cm) and subcutaneous fat thickness (SFT, cm).

3. Results and discussion

3.1. Descriptive statistics of traits

Descriptive statistics of average age, slaughter BW and carcass traits are presented in Table 1. The average age, slaughter BW, and CCW for the animals included in this study were 27.3 months, 635.5 kg, and 402.6 kg, respectively. The range of 316.0–502.6 kg for CCW in the present study was similar to the range of 350–499 kg reported by Mukai et al. (2004) for JB steers collected from 11 carcass-processing factories in 1998–2001. Thus the weight range appeared to be a good representative sample of the steers slaughtered in the Japanese carcass market.

Descriptive statistics of carcass composition, carcass tissue and individual carcass cut weights are presented in Table 2. The weights of carcass tissues and cuts were twice the weight of the left-side carcass