Prediction of cutability of beef carcasses processed in Jalisco State, Mexico

Predicción de la cortabilidad de canales de bovino en el estado de Jalisco, México


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Abstract

Previous study indicated the applicability of published equations into locally beef carcasses to predict total retail cuts expressed as total weight (TRC) or as percentage of carcass weight (TRYD). All such equations are based on variables requiring the ribbing of the half carcass. A limitation of such an approach in various regions of Mexico, Jalisco State included, responds to a traditional commercial evaluation of carcass without ribbing the halves carcasses into quarters, therefore the need to dispose of an alternative equation to predict cutability based on measurable variables from an intact half carcass. The objective of this study was the development of equation(s) to predict the cutability of beef carcasses not ribbed. The proposed equations are based upon available data from thirty carcasses coming from young bulls less than 36 months of age and undefined cross of zebu and European type, from a commercial butcher shop located at the metropolitan area of Guadalajara, Jalisco, Mexico and deboned using traditional Spanish style fabrication. Each retail cut and trimmings were weighed and summed to determine weight

Resumen

En un estudio previo se reportó la factibilidad de utilizar, en condiciones locales, ecuaciones disponibles de predicción de cortabilidad con base en kilogramos (TRC), o expresada como porcentaje de la canal (TRYD) de bovino. Todas las ecuaciones consideradas incluyen variables obtenidas en el cuarteo de una media canal, lo que representa una limitante para su adopción en regiones del país (el estado de Jalisco incluido), en donde la evaluación de las canales —previa a su comercialización— se lleva a cabo sin el cuarteo de la media canal. Esta condición marca la necesidad de disponer de ecuaciones de predicción que no se sustenten en variables generadas con el cuarteo de la media canal, lo que se convirtió en el objetivo de esta investigación. Las ecuaciones de predicción propuestas se basan en los datos obtenidos de la fabricación tipo corte español, de treinta canales de toretes crua indefinida cebú-europeo y menores a 36 meses de edad, procesadas en condiciones comerciales en una carnicería del municipio de Guadalajara, Jalisco, México. El peso de la canal fría mostró una correlación positiva (r=0.98) con el rendimiento de cortes expre-
of total retail cuts. Carcass weight had a positive correlation ($r = 0.98$) with weight of retail cuts. A model to predict weight of retail cuts indicated that carcass weight was the single most important variable explaining 95.60% of the variation. In conclusion, a simple equation is proposed relying only on carcass weight that will provide an initial adequate prediction based on available data and considered to be readily adopted.

**Keywords**
Meat, yield, prediction, retail cuts.

**Introduction**

It is recognized that progress in the livestock sector is based among others, on the development and application of tools designed to assist in the differentiation of the quality of the end product generated due to an intrinsic high degree of variation and its direct impact in its degree of confidence from the consumer (García et al., 2008). Therefore the application of tools to assist in the description of a beef carcass is considered beneficial. One strategy for the beef industry geared towards the achievement of a better definition of beef carcass merit at the market place is through the determination of yield in retail cuts, referred to as cutability (AMSA, 2001a;b), a component of beef quality.

At a commercial level, it is possible to estimate the retail cuts from a beef carcass through the use of equations to predict carcass cutability based on traits measurable manually on the whole carcass (Brungardt and Bray, 1963; Abraham et al., 1980; Johnson, 1987; Perry et al., 1993; Dolezal and Hilton, 2010) or automated (Ferguson et al., 1995). Although it may be considered questionable the use of predicting equations generated under contrasting conditions as to those applied, it has been reported (Zorrilla-Ríos et al., 2013) the applicability of published prediction equations generated for the USA beef industry into carcasses processed and fabricated under the Mexican conditions of the State of Jalisco. The seven published equations tested to predict total retail cuts as percentage bases of carcass weight (TRYD) on locally processed beef carcasses showed an adjusted $R^2$ of 0.279 to 0.355. When yield was expresses as kg bases (TRC), the estimated adjusted $R^2$ was 0.929 to 0.969. Regression analysis to predict TRYD included *Longissimus* muscle area (LMA), rib fat thickness (SCFAT) and kidney and pelvic fat (KPF) and excluded carcass weight (CW), and explained 44.50% of the variation. In contrast, regression analysis for TRC indicated that CW explained 95% of the variation, with minimal improvement when LMA and SCFAT variables were included.

Prediction equation based on variables obtained after ribbing the half carcass into a quarter portion would phase an impediment in its application at several beef markets in Mexico, Jalisco State include, as the traditional determination of the commercial merit of
the beef carcasses is performed on an intact half carcass. Therefore, the objectives of the present study were to propose alternate original equations to predict the market merit in terms of cutability of locally produced beef carcasses, based on independent and dependent variables feasible to be obtained without ribbing the half carcass into quarters, and the creation of a database upon which to improve and-or modify the equations proposed.

Materials and methods

Thirty beef carcasses from intact young bulls not older than 36 months of age of undefined breed crosses between zebu and European type, were fabricated into retail cuts of meat, total bone, total fat and trimmings in a commercial butcher shop situated in the metropolitan area of Guadalajara, Jalisco, Mexico. Animals were slaughtered at the Municipal Abattoir of Guadalajara, and the carcasses were split in half along the spinal column and chilled for 18 hr before being transported to the butcher shop. The carcasses made available for the present study were those carcasses which would correspond to the criteria traditionally used by the butcher in terms of conformation, weight and gender.

The kidneys, their surrounding fat and the pelvic fat remained attached to the carcasses. Each side of the carcass was ribbed between the 6th and the 7th ribs for the measurement of the Longissimus muscle area (LMA) by means of a grid placed on the cut surface of the ribeye and the thickness of the subcutaneous fat obtained at a point three-fourths of the distance of the length of the ribeye from its chine bone side. Hump height (HH) was measured with a ruler graded in cm as the distance between the highest point of the crest to a point perpendicular to the base of the hump. The circumference of the hind leg (LEG C) was estimated with a metric tape located at the femoral tibial-patellar join and around the middle portion of the Semitendinosus muscle (ICTA, 1995).

Individual weights on cold carcass, LMA, thickness of the subcutaneous fat at the 6th rib, hind leg circumference, hump height, total weight of bones, kidney and pelvic fat and trims were recorded without interfering with the team of workers deboning carcasses under the local traditional Spanish style fabrication described in SARH (1976). Total weight of retail cuts was calculated as the sum of the weight of all individual beef cuts. The sum of the weight of retail cuts and weight of kidney and pelvic fat were also expressed as percentage of cold carcass weight.

Not all observations had complete data, thus an imputation method was used to generate missing values for independent variables (table 1). Imputation methods are widely recognized for improving an experiment’s efficiency when there are missing data (Little and Rubin, 2002). Missing values were imputed using maximum likelihood estimates with the EM statement used to invoke the expectation-maximization algorithm for maximum likelihood estimation using means and standard deviations from available cases for the initial estimates in the EM algorithm (Proc MI; Version 9.3 for Windows, SAS Instit. Inc., Cary, NC USA, 2011). New equations were developed using the stepwise procedure (Proc Reg of SAS) to determine the order of importance of independent variables in the prediction of the dependent variable. Independent variables were sequentially added to the model to compute the coefficient of determination ($R^2$), adjusted $R^2$, and root mean
squared error (Proc Reg of SAS), and determine the optimum model to predict retail cuts and retail yield. Diagnostic measures were used to evaluate the appropriateness of the model.

Table 1
Summary statistics and abbreviations for independent and dependent variables in the initial and imputed datasets.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbr</th>
<th>Initial data set</th>
<th>Imputed data seta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass wt., kg</td>
<td>CW</td>
<td>30 287.5 62.6 451.7</td>
<td>287.5 62.7 202.6 – 451.7</td>
</tr>
<tr>
<td>Longissimus muscle area, cm²</td>
<td>LMA</td>
<td>29 74.55 12.03 96.50</td>
<td>74.58 11.82 56.0 – 96.5</td>
</tr>
<tr>
<td>6th rib fat thickness, mm</td>
<td>SCFAT</td>
<td>24 5.1 3.7 1.0 – 13.0</td>
<td>4.8 3.5 0.7 – 13.0</td>
</tr>
<tr>
<td>Kidney and pelvic fat, %</td>
<td>KPF</td>
<td>28 2.08 0.68 1.25 – 3.59</td>
<td>2.10 0.67 1.26 – 3.59</td>
</tr>
<tr>
<td>Hind leg circumference, cm</td>
<td>LEGC</td>
<td>24 84.02 7.42 104.0</td>
<td>84.07 6.86 75.0 – 104.0</td>
</tr>
<tr>
<td>Hump height, cm</td>
<td>HH</td>
<td>22 14.34 5.4 5.50 – 26.0</td>
<td>13.83 4.97 5.5 – 26.0</td>
</tr>
<tr>
<td>Total retail cuts, kg</td>
<td>TRC</td>
<td>30 212.6 47.9 347.7</td>
<td>212.6 47.9 149.6 – 347.7</td>
</tr>
<tr>
<td>Retail yield, %</td>
<td>TRYD</td>
<td>30 73.96 3.13 67.3 – 80.29</td>
<td>73.96 3.13 67.3 – 80.29</td>
</tr>
</tbody>
</table>

aAll imputed data correspond to 30 observations.

Based on residual plots and cumulative distribution plots (q-q plot), residuals were normally distributed with equal variance. Variance inflation factors were less than 2.0 indicating no multicolinearity among independent variables, and differences in fit and regression coefficients for individual observations (DFFITS and DFBETAS) were less than 1.0 indicating that none of the individual observations had a significantly greater influence on the regression coefficients than the other observations. Both original and imputed datasets...
were evaluated using the stepwise procedure and resulted in very similar equations. Only equations resulting from analysis of the imputed dataset are presented which provide maximum predictive ability from the complete dataset.

Results

From the summary statistics of independent and dependent variables for the initial and imputed datasets presented in table 1, it is important to note that the dependent variables, total retail cuts and retail yield did not have any missing values. The mean and standard deviation for LMA and KPF changed very little in the imputed dataset compared with the initial dataset due to the fact that only one or two observations had missing values for these variables. Fat thickness at the 6th rib (SCFAT), hind leg circumference (LEG), and hump height (HH) had the most missing values; however imputing values using the maximum likelihood estimation method did not affect the coefficient of variation (73 vs. 73%, 9 vs. 8%, and 38 vs. 36% for the initial and imputed datasets, respectively). In addition, the range in values did not substantially change which could have significantly affected the model prediction.

Pearson correlation coefficients among carcass measurements and the recovery of retail cuts are presented in table 2. In the initial dataset, CW, LMA, LEG, and HH were positively correlated with total retail cuts (TRC), but only LMA was positively correlated with retail yield (TRYD). Kidney and pelvic fat (KPF as % of CW) was negatively correlated with retail yield (TRYD). Correlation coefficients were similar in the imputed dataset with the exception that SCFAT was negatively correlated with retail yield (TRYD) compared to no significant correlation in the initial dataset. Although, the correlation coefficient between SCFAT and TRYD in the initial dataset was similar in direction to that in the imputed dataset among the independent variables, CW was positively correlated with SCFAT, LEG, and HH, LMA was negatively correlated with KPF, and HH was positively correlated with SCFAT, KPF, and LEG.

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Table 2
Pearson correlation coefficients among carcass measurements and yield of retail cuts for the initial (above diagonal) and imputed (below diagonal) datasets.

<table>
<thead>
<tr>
<th>Variable</th>
<th>TRC</th>
<th>TRYD</th>
<th>CW</th>
<th>LMA</th>
<th>SCFAT</th>
<th>KPF</th>
<th>LEGC</th>
<th>HH</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRC</td>
<td>0.19</td>
<td>0.98*</td>
<td>0.43*</td>
<td>0.26</td>
<td>-0.24</td>
<td>0.71*</td>
<td>0.58*</td>
<td></td>
</tr>
<tr>
<td>TRYD</td>
<td>0.19</td>
<td>-0.02</td>
<td>0.51*</td>
<td>-0.34</td>
<td>-0.38*</td>
<td>0.00</td>
<td>-0.08</td>
<td></td>
</tr>
<tr>
<td>CW</td>
<td>0.98*</td>
<td>-0.02</td>
<td>0.34</td>
<td>0.34</td>
<td>-0.18</td>
<td>0.73*</td>
<td>0.62*</td>
<td></td>
</tr>
<tr>
<td>LMA</td>
<td>0.42*</td>
<td>0.50*</td>
<td>0.33</td>
<td>-0.16</td>
<td>-0.51*</td>
<td>0.19</td>
<td>-0.09</td>
<td></td>
</tr>
<tr>
<td>SCFAT</td>
<td>0.32</td>
<td>-0.43*</td>
<td>0.41*</td>
<td>-0.22</td>
<td>0.23</td>
<td>0.24</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>KPF</td>
<td>-0.24</td>
<td>-0.38*</td>
<td>-0.17</td>
<td>-0.52*</td>
<td>0.28</td>
<td>-0.18</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>LEGC</td>
<td>0.68*</td>
<td>-0.14</td>
<td>0.72*</td>
<td>0.17</td>
<td>0.31</td>
<td>-0.16</td>
<td>0.65*</td>
<td></td>
</tr>
<tr>
<td>HH</td>
<td>0.59*</td>
<td>-0.16</td>
<td>0.63*</td>
<td>-0.05</td>
<td>0.49*</td>
<td>0.43*</td>
<td>0.62*</td>
<td></td>
</tr>
</tbody>
</table>

*TRC = total retail cuts (kg), TRYD = total retail yield (%), CW = cold carcass weight, LMA = Longissimus muscle area, SCFAT = 6th rib fat thickness, KPF = kidney and pelvic fat percentage, LEGC = circumference of the hind leg, HH = height of the hump.
*Correlation coefficient is different from zero at $P < 0.05$.

For the prediction of TRC, the stepwise procedure indicated that the order of inclusion in the model was CW, LMA, SCFAT, LEGC, HH, and KPF. The regression coefficients and fit statistics for the sequential addition of independent variables are presented in Table 3. Carcass weight as a single independent variable accounted for a large proportion of the variation observed for the weight of retail cuts (Model 1; $R^2$ of 0.956 and RMSE of 10.167).
Table 3
Regression coefficients (B ± SE) and fit statistics for stepwise selection of regression model to predict total retail cuts (TRC, kg) from the imputed dataset.

<table>
<thead>
<tr>
<th>Model</th>
<th>RMSE$^a$</th>
<th>Adj R$^2$</th>
<th>R$^2$</th>
<th>Intercept</th>
<th>CW</th>
<th>LMA</th>
<th>SCFAT</th>
<th>LEGC</th>
<th>HH</th>
<th>KPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.167</td>
<td>0.955</td>
<td>0.956</td>
<td>-2.664</td>
<td>0.749</td>
<td>± 8.861</td>
<td>± 0.030</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9.069</td>
<td>0.964</td>
<td>0.967</td>
<td>-27.170</td>
<td>0.722</td>
<td>± 11.654</td>
<td>± 0.028</td>
<td>± 0.151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8.761</td>
<td>0.967</td>
<td>0.970</td>
<td>-22.481</td>
<td>0.751</td>
<td>± 11.585</td>
<td>± 0.032</td>
<td>± 0.160</td>
<td>± 0.558</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>8.835</td>
<td>0.966</td>
<td>0.971</td>
<td>-5.771</td>
<td>0.773</td>
<td>± 25.105</td>
<td>± 0.044</td>
<td>± 0.162</td>
<td>± 0.563</td>
<td>± 0.348</td>
</tr>
<tr>
<td>5</td>
<td>8.940</td>
<td>0.965</td>
<td>0.971</td>
<td>-2.757</td>
<td>0.764</td>
<td>± 25.833</td>
<td>± 0.047</td>
<td>± 0.169</td>
<td>± 0.586</td>
<td>± 0.370</td>
</tr>
<tr>
<td>6</td>
<td>8.871</td>
<td>0.966</td>
<td>0.973</td>
<td>26.855</td>
<td>0.744</td>
<td>± 36.012</td>
<td>± 0.049</td>
<td>± 0.179</td>
<td>± 0.584</td>
<td>± 0.403</td>
</tr>
</tbody>
</table>

$^a$RMSE = root mean square for error; CW = cold carcass weight in kg; LMA = 6th rib Longissimus muscle area in cm$^2$; SCFAT = 6th rib fat thickness in mm; LEGC = hind leg circumference in cm; HH = hump height in cm; KPF = kidney and pelvic fat in percentage of carcass weight.
The incorporation of the independent variables LMA and SCFAT in model 3 provided the best prediction model with an adjusted $R^2$ of 0.967 and a RMSE of 8.761 kg. No further improvement in the accuracy of prediction was observed with the inclusion of LEGC, HH and KPF, as shown in Table 3.

Weight of retail cuts of the present study was calculated as a percentage of carcass weight, the best model included all independent variables (Model 11: LMA, SCFAT, LEGC, HH, and KPF) except for CW with an adjusted $R^2$ of 0.329 and RMSE of 2.565 percentage units (table 4).
### Table 4
Regression coefficients (B ± SE) and fit statistics for stepwise selection of regression model to predict retail yield as a percentage of carcass weight (TRYD) from the imputed dataset.

<table>
<thead>
<tr>
<th>Model</th>
<th>RMSE&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Adj R&lt;sup&gt;2&lt;/sup&gt;</th>
<th>R&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Intercept</th>
<th>LMA</th>
<th>SCFAT</th>
<th>LEGC</th>
<th>HH</th>
<th>KPF</th>
<th>CW</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>2.752</td>
<td>0.228</td>
<td>0.254</td>
<td>63.990</td>
<td>0.134</td>
<td>± 3.263</td>
<td>± 0.043</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2.601</td>
<td>0.310</td>
<td>0.358</td>
<td>66.846</td>
<td>0.114</td>
<td>± 3.375</td>
<td>± 0.141</td>
<td>-0.293</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2.621</td>
<td>0.299</td>
<td>0.372</td>
<td>70.983</td>
<td>0.123</td>
<td>± 6.366</td>
<td>± 0.044</td>
<td>-0.251</td>
<td>-0.059</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2.642</td>
<td>0.288</td>
<td>0.386</td>
<td>72.943</td>
<td>0.126</td>
<td>± 6.905</td>
<td>± 0.044</td>
<td>-0.297</td>
<td>-0.100</td>
<td>0.106</td>
</tr>
<tr>
<td>11</td>
<td>2.565</td>
<td>0.329</td>
<td>0.445</td>
<td>85.594</td>
<td>0.087</td>
<td>± 10.397</td>
<td>± 0.165</td>
<td>-0.301</td>
<td>-0.201</td>
<td>0.296</td>
</tr>
<tr>
<td>12</td>
<td>2.614</td>
<td>0.304</td>
<td>0.448</td>
<td>85.410</td>
<td>0.092</td>
<td>± 10.610</td>
<td>± 0.172</td>
<td>-0.283</td>
<td>-0.189</td>
<td>0.326</td>
</tr>
</tbody>
</table>

<sup>1</sup>RMSE = root mean square for error; CW = cold carcass weight in kg; LMA = 6th rib Longissimus muscle area in cm²; SCFAT = 6th rib fat thickness in mm; LEGC = hind leg circumference in cm; HH = hump height in cm; KPF = kidney and pelvic fat in percentage of carcass weight.
Discussion

The sample size used in this study (N = 30) compares favorably to the 22 observations used in the study of Kauffman et al. (1975), with the 40 carcasses included in the study of Johnson (1987) and could also be considered proportionally comparable to the sample size employed in the study of Murphey et al. (1960) which gave rise to a prediction equation published previously (Dolezal and Hilton, 2010). The equation developed by Murphey et al. (1960) was based on the fabrication of 162 carcasses out of a population of 27,500,000 sent to slaughter at the time (NASS, 2009), an equivalent to one carcass fabricated for every 170,000 carcasses produced. In the present study, 30 beef carcasses were fabricated out of an estimated population of 4,200,000 slaughtered in Mexico (AMEG, 2006), which gives a ratio of one fabricated carcass for every 135,480 carcasses produced. Therefore, even though the number of observations used in the current study is small compared to that of Murphey et al. (1960: 30 vs. 162 carcasses), the proportion of the total population is similar.

In contrast to our study, the studies of Abraham et al. (1968), Cole et al. (1962), and Dikeman et al. (1998) reported that percent kidney and pelvic fat was also an important independent variable in the prediction of weight of retail cuts. Differences in the degree of fatness in carcasses of the current study compared with previous studies may be partially responsible for such a discrepancy.

Model 3 provided the best prediction model when yield of retail cuts are expressed in weight basis, with an adjusted R² of 0.967 and a RMSE of 8.761 kg with the incorporation of the independent variables LMA and SCFAT. However, no further improvement in the accuracy of prediction was observed with the inclusion of LEGC, HH and KPF, as shown in table 3. Similar to previously published equations (Cole et al., 1962; Abraham et al., 1968; Cross et al., 1973; Perry et al., 1993; Dikeman et al., 1998), CW, LMA, and SCFAT are the most important variables to predict weight of retail cuts due to the fact that they provide information about weight, musculature, and fat deposition which affect the amount of retail cuts.

Published prediction equations for estimating cutability express the output of retail cuts as percentage of carcass weight (Murphy et al., 1960; Cross et al., 1973; Kauffman et al., 1975; Abraham et al., 1980; Johnson, 1987; Perry et al., 1993; Dikeman et al., 1998; Dolezal and Hilton, 2010) instead of an absolute weight. When weight of retail cuts of the present study was calculated as a percentage of carcass weight, the best model included all independent variables (Model 11: LMA, SCFAT, LEGC, HH, and KPF) except for CW with an adjusted R² of 0.329 and RMSE of 2.565 percentage units (See table 4), as previously indicated by Johnson (1987). The fact that CW is not an important variable to explain the variation in percentage of retail cuts is expected due to the amount of retail cuts already being adjusted for differences in CW.

However, many previous studies (Murphey et al., 1960; Cross et al., 1973; Abraham et al., 1980; Dikeman et al., 1998) have reported that carcass weight is an important independent variable in the model to predict retail cuts as a percentage of carcass weight.
Abraham et al. (1980) reported that including carcass weight improved the $R^2$ from 0.82 to 0.83 compared with rib fat thickness, kidney, pelvic and heart fat, and longissimus muscle area alone. Interestingly, Abraham et al. (1968) reported that the partial correlation coefficient for carcass weight was 0.85 when retail cuts were expressed on a weight basis, but was -0.16 when retail cuts were expressed on a percentage of carcass weight basis and rib fat thickness, longissimus muscle area, and kidney fat were constant in each model.

The ability of the independent variables to explain the variation in percent retail cuts in Model 11 (table 4) was considerably lower compared with Model 3 to predict weight of retail cuts ($R^2 = 0.445$ vs. $0.970$, respectively). Cross et al. (1973) found that the Murphey equation and the USDAs cutability equation explained 74 and 69% of the variation in observed percent retail yield of 82 carcasses used in their study. Similarly, Abraham et al. (1968) and Dikeman et al. (1998) reported that the ability of the independent variables to explain the variation in percent retail cuts was lower than for weight of retail cuts ($R^2 = 0.63$ vs. 0.93 and 0.75 vs. 0.90, respectively).

The lower predictive ability of the independent variables when retail cuts are expressed as a percentage is most likely due to the small predictive ability of the independent variables above that of $cw$ alone. When predicting weight of retail cuts, including all independent variables in Model 6 only resulted in a 1.7 percentage unit increase in the $R^2$ above Model 1 with $cw$ alone. Expressing retail cuts as a percentage of $cw$ is essentially accounting for that variation due to $cw$ similar to Model 1, and thus, there is little variation not accounted for due to the fact that $cw$ accounts for 95% of the total variation. The coefficient of variation for weight of retail cuts was 22% compared with 4% for percent of retail cuts significantly reducing the variation in retail yield.

In our study the weight of the carcass as a single independent variable had a high degree of accuracy to predict the weight of retail cuts (Model 1; $R^2 = 0.955$; RMSE = 10.167). The simplicity of application of such an equation is considered an advantage over alternative equations that would require the ribbing of the carcass in order to obtain measurement of any other independent variables, as ribbing of the carcass is a practice only accepted as a conventional procedure for the visual evaluation of the marketing merit of a carcass in restricted regions of Mexico. Thus, the lack of experience by the entire beef industry on the application of a cutability equation involving $lma$ or $scfat$ supports the initial use of carcass weight alone to estimate the total retail cuts obtainable from a beef carcass subjected to the Spanish style of fabrication.

Scientific knowledge is built gradually. Its application as a technological tool is also a gradual process. A prediction equation is a technological tool subject to experience improvement step by step. The equation to predict beef carcass yield in the USA was published in 1965 and gone to a series of adjustments since. Therefore the proposed equations should be interpreted as contributions towards a set goal: offer means to differentiate the market value of a beef carcass which in its application would benefit the entire food chain.

As one of the objective of the present study was to establish a database upon which to develop equation(s) based on independent and dependent variables to predict the
cutability of beef carcasses generated locally, regionally and eventually nationally, it would be expected that the accuracy of the equations proposed here would be improved as the database is expanded. The Mexican beef industry is based on a wide range of breeds and their crosses together with a contrasting production system, which is similar to many countries. These circumstances are responsible for the wide range of conformation and degree of fatness observed in the beef population. Currently, our database includes typical ranges of conformation and fatness for cattle harvested in Jalisco State, and thus is applicable to this geographical region of Mexico. Additional data will need to be collected from other geographical regions incorporating different breeds and production systems that will allow us to develop a prediction equation applicable to all of the Mexican beef industry. Eventually, as more data are incorporated in the database, factors such as breed (Graham et al., 2009), nutritional background, and even geographical origin could be considered for incorporation (Ferguson et al., 1995).

Conclusions

Equations using thickness of the subcutaneous fat and area of the Longissimus muscle did not explain a substantial amount of variation in weight of retail cuts above carcass weight alone. However, when retail cuts were adjusted for differences in carcass weight (percentage of carcass weight), Longissimus muscle area and thickness of the subcutaneous fat explained a significant amount of variation, but due to the expected lack of adoption of this equation due to ribbing of the carcass, we suggest that a simple equation using only carcass weight is recommended at this time. The authors recognize that further research is needed to identify those factors that could significantly improve the accuracy of an equation to estimate cutability beyond that based on the weight of the beef carcass. Its application would contribute to the establishment of differences in their commercial merit under the wide range of Mexican production systems, the genetics of the population, and carcass fabrication into retail cuts among others.

Cited Literature


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