EVALUATION OF THE CANADIAN AND UNITED STATES BEEF YIELD PREDICTION EQUATIONS AND DUAL ENERGY X-RAY ABSORPTIOMETRY FOR A RAPID, NON-INVASIVE YIELD PREDICTION IN BEEF

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Abstract – The aim of the present study was to evaluate the North America beef yield equations and the potential use of DEXA technology for yield predictions, either total or saleable, for beef carcasses. A total of 238 left carcass sides were broken down into main primal and retail cuts. All the cuts were scanned with an iDXA unit and then fully dissected into fat (subcutaneous (SQ), intermuscular (IM) and body cavity (BC)), lean and bone and weighed. The relationship between the Canadian and USDA yield estimations and the SQ (R^2=0.58 and 0.52) or lean (R^2=0.54 and 0.56) content were relatively low. The relationship between USDA yield estimation and actual saleable yield of the boneless, closely trimmed round, loin, rib and chuck retail cuts was also low (R^2=0.38). DEXA technology showed high accuracy for the total fat (R^2=0.95) and lean (R^2=0.86) meat yield estimations and also for the rib (R^2 = 0.86) and chuck (R^2 = 0.83) saleable yield estimations. The present results suggest that the accuracy of the yield equations used on the current beef population may require updating to reflect the current market population. In addition, DEXA technology may have the potential to estimate beef carcass traits such yield performance.

Key Words – beef yield algorithms, carcass cut-out, fat, lean, saleable yield.

I. INTRODUCTION

In North America, beef carcass composition or yield evaluation plays an important role for determining carcass market value. Also yield analyses are fundamental for the evaluation of growth and for genetic selection in animal production.

Currently, there are essentially two algorithms in use based on the main yield assessment approaches, either saleable or total lean meat yield. In the Canadian Grading System all youthful top grade carcasses are also assessed in terms of their cutability (the estimated yield of lean meat) and are assigned a yield grade. The estimated total lean yield is assessed with a grade ruler according to the Canadian equation estimations [1] with break points at 59% or more, ≤58 to ≥54% and 53% or less for Canada 1, 2 and 3 carcasses, respectively.

In contrast, the United States Department of Agriculture (USDA) employs a yield algorithm based on the yield of closely trimmed (0.76 cm or 0.30 in), boneless retail cuts from four primal cuts (round, loin, rib and chuck; [2]). There are 5 USDA yield grades, with the following break points at ≥52.3%, <52.3 to ≥50.0%, <50.0% to ≥47.7, <47.7 to ≥45.4 and <45.4% for USDA yield grades 1, 2, 3, 4 and 5, respectively.

Canadian and USDA beef yield algorithms were developed 20 and 50 years ago, respectively. The ongoing evolution of the market cattle population, as well as improved management strategies during the last decades has led to changes in cattle populations that may have influenced the accuracy of these yield equations. Value based marketing is a reality in the beef industry, and accurate prediction methods and equations are required for determining amount of beef yield, either saleable or total lean meat.

Dual energy X-ray absorptiometry (DEXA) is an alternative technique that has been successfully used to measure body composition in humans [3] and more recently in pork [4] and beef [5]. This technique has the capability to measure bone mineral content (BMC) and density (BMD), lean tissue mass, fat tissue mass, and percentage fat. Recently there has been an increased interest in using DEXA technology because of its low cost, speed of data collection, reliability and ease of use, compared with other technologies. Hence, DEXA holds promise as an indirect method of estimation of the composition of the carcasses.

Therefore, the aim of the present study was to evaluate the beef yield equations currently used in North America and the potential use of the DEXA technology to predict either total or saleable yield of beef carcasses.

MATERIALS AND METHODS

A total of 238 crossbreed steers finished on a common commercial diet were used to evaluate the Canadian and USDA beef yield algorithms. All the animals were maintained and cared for according to the guidelines of the Canadian Council on Animal Care [6]. Cattle were weighed and ultrasounded monthly (using an Aloka 500V diagnostic real time ultrasound machine with a 17-cm 3.5-Mhz linear array transducer; Overseas Monitor Corporation Ltd., Richmond, BC) and steers were serially slaughtered from 300 to 800 kg of live weight and at ultrasound backfat depth end points from 2 to 20 mm.

Following splitting of the carcasses, hot carcass side weights were recorded. After conventional chilling at 2°C for 24 h, left and right carcass sides were weighed to determine cooler shrink loss. Then, both carcass sides were knife-ribbed at the Canadian grade site, between the 12th and 13th rib. After 20 min exposure to atmospheric oxygen, full blue tag Canadian grade data were assessed by a certified grader from the Canadian Beef Grading Agency. The assessment included fat thickness (fat thickness over the rib at ¼, ½ and ¾ position from the spinous process), grade fat (minimum fat thickness over the rib in 4th quadrant from the spinous process), rib-eye area (REA: in cm^2 of the *longissimus lumborum*), estimated lean yield from Canada grade [7] and marbling score was assessed subjectively using USDA beef marbling pictorial standards as reference points [8]. Carcasses were fabricated following normal commercial conditions in plant or in meat laboratory facilities. Carcass break points were identified following USDA [9] Institutional Meat Purchase Specifications (IMPS) for Fresh Beef Products, Series 100. The primals collected from the left fabricated carcass side were the chuck (IMPS #113), rib (IMPS #103), brisket (IMPS #118), flank (IMPS #193, non-trimmed), foreshank (IMPS #117), loin (IMPS #172A), round (IMPS #158A) and plate (IMPS #121) primal cuts. Each primal cut was scanned with a Lunar iDXA unit (GE Lunar Prodigy Advance, General Electric, Madison, WI, USA) using the whole body scan option on the standard mode to estimate DEXA fat, lean and bone tissues. After the DEXA scanning, each left round, loin, rib and chuck primals were further fabricated into boneless, closely trimmed (0.76 cm or 0.30 in) retail cuts, weighed and iDXA scanned. Finally, all left primal and retail cuts were fully dissected into SQ, IM, BC fat, lean and bone and weighed by qualified personnel.

All statistical analyses were performed using SAS 9.3 [10]. The PROC REG was used to evaluate the relationship of the variables. Single and stepwise regression model procedures were used to analyze the data. The accuracy of prediction was evaluated in terms of coefficient of determination (R^2) and root mean square error (√MSE). For stepwise regression, a significance level of $P < 0.05$ for entry and retention of the variables within the equations was applied.

II. RESULTS AND DISCUSSION

Carcass weight (192 - 453 kg), grade fat (1.0 - 20.0 mm), estimated lean yield (50.0 - 65.0 %), rib-eye area (48.0 - 114.0 cm^2) and marbling score (220 - 650) values of the carcass population used in the present study were within the actual range (Table 1) of the Canadian beef carcass market [11]. Likewise, the sample population used was represented by yield grade groupings of 67 % Canada 1, 30.5 % Canada 2 and 2.5 % Canada 3 and quality grades of 42.0 % Canada AAA, 51.3 % Canada AA and 5.9% Canada A. These grades were representative of the current Canadian marketable beef carcass population (data not shown).

Table 1 Descriptive statistics of carcass characteristics for the population used in the present study.

Characteristic	n	Mean	SD[a]	Min	Max
Carcass weight, kg	238	308.7	48.63	192.2	452.8
Top, mm	238	12.8	4.79	3.0	31.0
Middle, mm	238	9.50	3.75	2.0	22.0
Bottom, mm	237	8.56	3.59	1.0	21.0
Grade fat, mm	236	7.98	3.49	1.0	20.0
REA[b], cm^2	238	77.2	10.75	48.0	114.0
Estimated lean yield, %	236	59.4	2.65	50.0	65.0
Marbling score[c]	237	386.0	59.33	220.0	650.0

[a]SD: Standard deviation.

[b]REA: Rib eye area in cm^2 of the *longissimus lumborum.*

[c]USDA pictorial standards

The coefficient of determination obtained between the Canadian and USDA yield equation estimates was relatively high (R^2=0.75). However, relationships between the Canadian and USDA yield estimations and the actual (dissection) SQ or lean content were low (R^2=0.58 and 0.52, for SQ and R^2=0.54 and 0.56, for lean, respectively) (Table 2). The relationship between USDA yield estimations and total of lean and fat percentage (saleable yield) in the boneless, closely trimmed round, loin, rib and chuck retail cuts, on which the USDA equation is based, was also low (R^2=0.38). Previous studies [12, 13] have reported the subjectivity and inaccuracy of the current yield determinations, especially for the saleable yield. These results demonstrate the need to reconsider beef yield estimations as well as the importance of the implementation of technology in order to improve these assessments.

Table 2 Relationship (R^2)[a] between the Canadian and USDA yield values estimated through the equations and the actual yield values of lean, subcutaneous (SQ), body cavity (BC), and intermuscular (IM) fat depots in the full carcass cut-out and in the 4 main USDA primals (round, loin, rib and chuck).

Relationship	n	Lean	SQ	BC	IM
Canadian Lean Yield vs. full carcass cut-out	236	0.54	0.58	0.11	0.44
USDA Yield vs. round, loin, rib, and chuck cut-out	234	0.56	0.52	0.09	0.39

[a]R^2: coefficient of determination

Recently studies have reported the reliability of DEXA technology for yield estimations in pork [4] and beef [5]. Aligned with these findings, in the present study, DEXA technology showed high accuracy for the total fat (R^2=0.95) and lean (R^2=0.86) meat yield estimations (data not shown). Regarding the saleable yield predictions using DEXA technology, although R^2 values for the main primals were slightly lower (Table 3) than those for total fat and lean estimations, the percentage of variance explained by the model for the prediction of saleable yield content were also high for the rib (R^2 = 0.86) and chuck (R^2 = 0.83) while the R^2 values found for round (R^2 = 0.79) and loin (R^2 = 0.66) were slightly lower.

Table 3 Relationship (R^2)[a] between the actual boneless, closely trimmed retail cuts yield (saleable yield) and the dual-energy x-ray absorptiometry estimated saleable yield values for the different main primal cuts (round, loin, rib and chuck).

Beef primal	n	Saleable yield)
Chuck	238	0.83
Rib	235	0.86
Loin	237	0.66
Round	234	0.79

[a]R^2: coefficient of determination

Previous studies [14] have reported that estimated yield differences could be attributed partially to differences in seam fat deposition. Likewise, in practice, the fabrication of the boneless, closely trimmed round, loin, rib and chuck retail cuts is performed manually by meat cutters. Although these factors might introduce variations in the cutability, the present results suggest that dual energy X-ray absorptiometry technology has the potential to estimate beef carcass traits such saleable yield performance. However, further analyses are required to implement robust equations to attain precision and accuracy before using for routine predictions of carcass yields. Also, relationships amongst equations based on primals, sub-primals and trimmed retail cuts should be established.

III. CONCLUSION

The present results suggest that the accuracy of the yield equations applied to the current beef population may have been eroded by the ongoing evolution of the market cattle population. Improvements to the lean yield algorithms, using new technologies such as dual energy x-ray absorptiometry, could benefit the industry by more accurately identifying animals with superior carcass lean meat yield, thereby enhancing selection decisions and overall industry sustainability.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge funding support from Canadian Beef Grading Agency (CBGA), Alberta Livestock and Meat Agency Ltd. (ALMA), Beef Cattle Research Council (BCRC) of Canada, Livestock Gentec University of Alberta, and the in-kind contribution of animals, facilities and people received from Agriculture and Agri-Food Canada (AAFC), Lacombe Research Centre, AB, Canada. The authors thank the Alberta Crop Industry Development Fund (ACIDF) for funding support of Dr. Nuria Prieto. We also wish to thank the significant technical contributions of Fran Costello, Stan Landry, Mike Hamilton and Rhona Thacker. Also thanks are extended to Cletus Sehn, Ken Grimson, and their staff at the Lacombe Research Centre Beef Unit of AAFC for animal care and animal management. Special thanks are extended to Mr. Chuck Pimm and the Meat Processing staff at AAFC for animal slaughter and carcass data collection. Aymes Medical technical support is also much appreciate.

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