USE OF OBJECTIVE CARCASS CONFORMATION MEASUREMENTS TO ESTIMATE RED MEAT YIELD IN CALF-FED DAIRY TYPE STEERS

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Abstract – Post-harvest carcass conformation images of forty-six calf-fed dairy type (Holstein n=38, Jersey n=8) steers were quantified for area and distance measures which were subsequently used to calculate regression models to estimate red meat yield. Twenty-three of the steers had been fed zilpaterol hydrochloride (ZH) for 20 days prior to harvest whilst the remaining steers did not receive the β-adrenergic agonist (non-ZH). Digital images of the medial and ventral surfaces of right carcass sides were objectively measured using image analysis software. Carcasses were fabricated into subprimals common to the North American beef industry to quantify red meat yield per carcass. Two red meat yield prediction models were developed; one with a ZH effect and one without. The first model included ZH treatment (yes or no), round width, chuck width, carcass length, and internal cavity area measures (Adjusted R^2=0.31; *P* = 0.0011; RMSE = 3.0); the second model included chuck width and maximum width measures (Adjusted R^2 = 0.11; *P* = 0.0281; RMSE = 3.4). These data illustrate opportunity to utilize modern technology to improve carcass-based estimates of red meat yield.

Key Words – Digital image, Holstein, Regression, Zilpaterol Hydrochloride

I. INTRODUCTION

The USDA yield grade equation has been shown to require an unrealistic linear relationship between ribeye area and hot carcass weight (Lawrence *et al.* [1]) and to lack the ability to accurately quantify red meat yield in Holstein steers (Lawrence *et al.* [2]). Data for which the USDA yield grade calculation is based were compiled in the 1950s (Murphey *et al.*[3]). Since 1965 when the yield grade equation was implemented, many changes in genetics, growth management, feeding management, and finished weight have occurred in the beef industry. Considering the current technologies available, an objective, accurate, inexpensive, and repeatable method of calculating red meat yield would be welcomed by beef producers and processors.

Digital image analysis is currently being used to evaluate unribbed beef carcass muscle conformation for classification according to the EUROP [4] scale. Muscle conformation estimates derived from digital image analysis have been illustrated to account for 70% of the variation in red meat yield (Borggaard *et al.* [5]).

The objective of this research was to assess the ability to estimate salable red meat yield using objective carcass conformation measures.

II. MATERIALS AND METHODS

Forty-six fed dairy (Holstein n=38, Jersey n=8) steers were harvested using typical commercial practices at the West Texas A&M University Meat Laboratory (USDA Food Safety and Inspection Service Establishment Number 7124).

Carcass Fabrication

Carcass sides were fabricated into standard Institutional Meat Purchase Specifications (IMPS) cuts produced by North American commercial boxed beef processors (USDA [5]). Weights of subprimal briskets (IMPS 120), flanks (IMPS 193), and KPH fat were obtained. Foreshanks (IMPS 117) were fabricated into boneless lean. Primal chucks (IMPS 113) were fabricated into chuck eye rolls (IMPS 116D), chuck tenders (IMPS 116B), top blades (IMPS 114D) and arm roasts (IMPS 114E). Primal ribs (IMPS 103) were fabricated into ribeye roll-lip on (IMPS 112A) and back ribs (IMPS 124). Primal plates (IMPS 121) were fabricated into outside skirts (121C) and boneless Japanese plates (23cm x 28cm rectangle, no known IMPS code). Primal loins were fabricated into strip loins (IMPS 180), full tenderloins-side muscle off (IMPS 190), and top sirloin butts (IMPS 184). Rounds (IMPS 158) were fabricated into: knuckles peeled (IMPS 167A), top rounds (IMPS 169), outside rounds (171B), and eye of rounds (171C). Subprimals were trimmed to a maximum fat depth of 6 mm. Trim components for ground beef (IMPS 136) were visually trimmed to a minimum of 80% lean and chemically assessed using proximate analysis via the procedures of Novakofski *et. al.*[6]. Ground beef samples were oven dried and then weighed to determine moisture content. Fat was extracted using $CHCl_3$: methanol (4:1) and weighed again. Fabrication yields were calculated as a percentage of cold carcass weight. Subprimal weights were combined and expressed as a percentage of cold carcass weight to represent the red meat yield (%RMY) from each carcass.

Images and Image Analysis

Medial and ventral images of each right carcass side were obtained (Nikon Coolpix S550, Nikon, Melville, New York) immediately following final FSIS inspection. For software calibration purposes, the carcass sides were presented in front of a grid containing three-hundred and sixty four 100 cm^2 squares, each of contrasting black or green colors. Two-dimensional measurements obtained from the medial image included: total carcass area, area of the empty internal body cavity, net area (difference of total carcass area and area of the empty internal body cavity), round area, sirloin area, loin area, rib area, and chuck area; one-dimensional measurements included carcass length (distance from 1st rib to cranial tip of aitch bone), width of round, width of sirloin, width at 12th and 13th rib, and width of chuck (Figure 1). The two-dimensional measurement obtained from the ventral view was of carcass area whereas one-dimensional measurements included minimum carcass width and maximum carcass width. These measurements and methods to acquire such objective conformation measurements has shown little presence in published literature. For equivalent comparisons across carcass sizes, all area and distance measures were subsequently divided by their respective hot carcass weight for statistical analysis in regression models. Image measurements were quantified using digital analysis software (APS Assess 2.0, APS Press, St. Paul, Minnesota).

Statistical Analysis

Regression models were generated using the REG procedure of SAS (SAS Institute, Inc., Cary, NC). Model selection was guided using a backward elimination algorithm. Two models were generated, one which included the effect of ZH treatment, and one that did not.

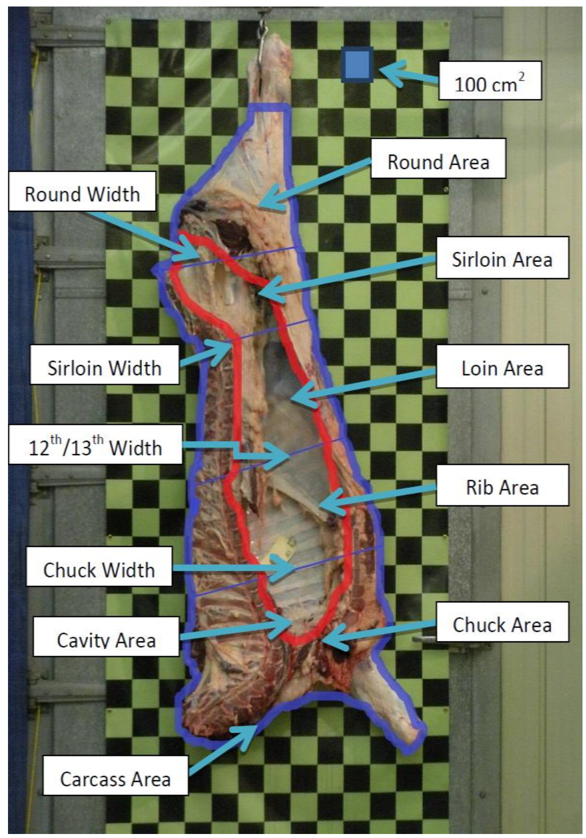

Figure 1. Medial image of beef carcass side illustrating carcass conformation measurements

III. RESULTS AND DISCUSSION

Descriptive statistics of the sample population are reported in Table 1. Additional data not shown in tabular form include LM area and subcutaneous fat depth of the sample population, which were 80.14 cm^2 and 0.69 cm, respectively. Compared to the dairy-type population from the 2008 National Beef

Quality Audit (Garcia *et al.* [8]), the sample cattle were trimmer (-0.42 cm) and lighter muscled (-3.7 cm^2) with heavier HCW (+9.8 kg). When compared to Boler et al. [9], the sample population revealed lower (-6.44%) %RMY. The large separation is likely attributed to heightened trimming specifications and differing fabrication methods.

Table 1. Descriptive statistics of sample carcasses

Item	Mean	Std. Dev.
Hot carcass weight, kg	380.5	55.5
Red meat yield, %	62.0	3.6
Trim fat, %	16.8	3.1
Medial carcass area, cm^2	11602	1132
Medial round area, cm^2	1919	270
Medial sirloin area, cm^2	1575	216
Medial loin area, cm^2	1987	277
Medial rib area, cm^2	2087	315
Medial chuck area, cm^2	3548	391
Medial cavity area, cm^2	3445	398
Medial net area, cm^2	8157	894
Medial round width, cm	50.8	3.1
Medial sirloin width, cm	44.8	3.2
Medial 12/13th width, cm	56.9	5.6
Medial chuck width, cm	69.5	3.3
Medial carcass length, cm	139.2	8.9
Ventral carcass area, cm^2	5948	635
Ventral maximum width, cm	31.5	2.1
Ventral minimum width, cm	24.1	2.5

Backward elimination regression yielded two models to predict fabricated red meat yield of calf-fed dairy type steers. A five parameter model that included the effect of ZH treatment was represented by the equation *RMY = 49.8525 + (2.9597 if fed zilpaterol) + (128.1618 * round width:hot carcass weight) - (110.3812 * chuck width:hot carcass weight) + (71.2612 * carcass length:hot carcass weight) – (1.3807 * cavity area:hot carcass weight).* This equation explained 31.22% of the variation in red meat yield of calf-fed dairy type steers (Figure 2). The ZH administration effect was the single greatest predictor of fabrication yield, accounting for 13% of the variation in red meat yield. As indicated by the equation, yield increased as round width increased, illustrating the positive relationship of muscle conformation in the round to the percentage of red meat yield within a dairy type carcass. As carcass length increased yield increased, attributable to more volumetric space for additional red meat accretion. Conversely, yield deteriorated as chuck width increased, likely due to the high percentage of bone and intermuscular fat contained within the subprimal. Cavity area was a measurement taken from the medial side of the carcass and contained the empty area occupied *in vivo* by the pluck and viscera. As this empty area increased, the volumetric space available for deposition of muscle tissue decreased.

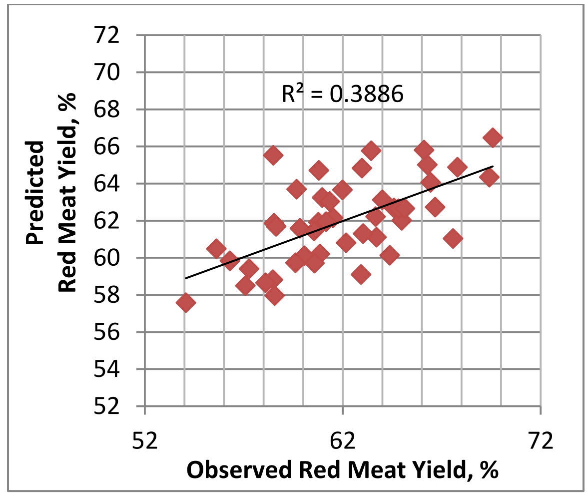

Figure 2. Observed and predicted percentage red meat yield of calf-fed dairy-type steers.

A two parameter model that did not include the effect of ZH treatment was represented by the equation *RMY = 57.24374 - (86.15383 * chuck width:hot carcass weight) + (245.64856 * maximum width:hot carcass weight).* This equation only explained 15.31% of the variation in red meat yield of calf-fed dairy type steers. Yield is shown to increase as maximum width increases as this would be an indication of greater conformation; however chuck width remains a negative effect on yield, likely due to high levels of intermuscular and subcutaneous fat and bone in this area.

Applying simple regression techniques of the sample population to evaluate the ability of the USDA calculated yield grade to predict actual RMY%, a less than desirable relationship ($R^2 = 0.18$; $P = 0.0021$; RMSE = 3.3) was found, suggesting the equation that includes ZH treatment stands as an improvement over the current method.

IV. CONCLUSION

Because the beef industry rewards high yielding carcasses and discounts low yielding carcasses, enhancements in grading practice and prediction methods could be improved using the methods shown in this study. The increase in ability to predict salable red meat yield in calf-fed dairy type carcasses using easily obtainable conformation images could aid in correct payment for actual yields as well as increased ability to sort carcasses into more homogenous groups prior to fabrication.

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