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Cull sow knife-separable lean content evaluation at harvest and lean mass content prediction equation development☆

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ABSTRACT

The objectives of this study were to develop a prediction equation for carcass knife-separable lean within and across USDA cull sow market weight classes (MWC) and to determine carcass and individual primal cut knife separable lean content from cull sows. There were significant percent lean and fat differences in the primal cuts across USDA MWC. The two lighter USDA MWC had a greater percent carcass lean and lower percent fat compared to the two heavier MWC. In general, hot carcass weight explained the majority of carcass lean variation. Additionally, backfat was a significant variation source when predicting cull sow carcass lean. The findings support using a single lean prediction equation across MWC to assist processors when making cull sow purchasing decisions and determine the mix of animals from various USDA MWC that will meet their needs when making pork products with defined lean:fat content.

1. Introduction

The ability to predict the percent carcass lean is necessary to sort cull sows to meet the processing needs for the pork products manufactured. Lean content and percentage lean prediction equations have been developed for market hogs in the US (Fahey et al., 1977). In Canada, Aziz, Rae, Allan, and Ball (1993) and Aziz, Rae, and Ball (1993) developed equations for cull sows, or sows removed from the breeding herd, using backfat probe measurements, loin width and depth measurements, and fat depth measured at different places along the loin. Jungst, Jones, Brown, Kuhlers, and Little (1989) reported lean prediction equation for cull sows; however, this work is over 20 years old and body composition from modern maternal sow lines has certainly changed since that time. Additionally, these equations do not consider the USDA cull sow market weight class (MWC) and do not take advantage of ultrasound measurements. Hence, lean prediction equations should be updated so they more accurately predict lean content produced from modern cull sows.

It is important to know if one equation across all USDA cull sow MWC is as predictive as individual equations for each cull sow MWC. Ultrasound measurements do not require carcass adulteration, and can be taken in a time and cost efficient manner. Ultrasound measurements can be used to predict the animal's lean content before the animal is slaughtered (Liu & Stouffer, 1995). The objectives of this study were to 1) estimate the primal knife-separable lean and fat content from the four USDA cull sows MWC, and 2) establish standardized prediction equations for estimating cull sow lean content using carcass and ultrasonic backfat and loin muscle area measurements.

2. Materials and methods

The project utilized 185 carcasses which originated from commercially available maternal line cull sows produced by area commercial pork operations near Ogden, Utah. The cull sows were harvested and carcasses processed at a commercial abattoir (Old McDonalds Meats, Ogden, UT) under USDA inspection supervision. Carcasses were classified based on the sow's live weight (USDA cull sow weight categories 1, 2, 3, and 4). The USDA cull sow weight classes are based on the following live weight classes: class 1 (136.1 to 204.1 kg), class 2 (204.2 to 226.8 kg), class 3 (226.9 to 249.5 kg), and class 4 (249.6 kg and greater). Prior to harvest, ultrasonic backfat and loin muscle area were obtained by a trained technician using an Aloka 500 V Real Time ultrasound machine (Corometrics Medical Systems, Wallingford, CT). Sows were rendered unconscious using an electric stunner and exsanguinated (Best & Donovan, Cincinnati, OH).

Carcasses were split using a Jarvis Products Corporation-J B 160 circular splitting saw (Middleton, CT). Each half of the carcass was weighed to ensure an accurate split. After the carcass was split, half of the carcass was dissected into primal cuts (shoulder, loin, ham and rib and belly, North American Meat Processors Association

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(NAMP), 2007) and primal cut weights were recorded. The side to further process was randomly chosen by plant personnel. Primal cuts were weighed using a 91 kg capacity Weigh Tronix Model 3275 (Fairmont, MN) that is accurate to 0.02 kg. Primals were then dissected into knife separable lean, fat, skin and bone and respective weights were recorded. Harvest facility owners were trained by Iowa State University meat laboratory personnel to dissect the cull carcass into primal cuts and further separate the primal cuts into its knife-separable tissue components (lean, fat, bone, and skin).

Several carcass measures were obtained: 1) carcass weight, 2) approximately 10th rib backfat measured approximately 6.3 cm off-midline, and 3) approximately 10th rib loin muscle area. Loin muscle area was measured using a plastic grid (Iowa State University, 1994) or by tracing the loin on acetate paper and measuring the tracing at a later time. Live weights were measured on a Ferguson–Hanks Corp Model 1200 B scale (Chicago, IL). Carcass weights were taken on a Weigh Tronix Model W I 125 digital rail scale (Fairmont, MN).

The sum of the lean content from each primal was divided by the weight from the entire side processed to determine the percentage weight for each primal. To calculate total lean content, it was assumed that the side of the carcass not processed would contain the same lean content percentage as the side processed (Prince et al., 1981). Additionally, this method was used to determine the relative proportion that skin, bones, and fat made up from each primal, carcass side, entire carcass, and live sow weight. A total of 176 sow carcasses met the criteria for inclusion in the analysis (67 sows in MWC 1, 38 in MWC 2, 34 in MWC 3, and 37 in MWC 4). All carcasses that went through the plant during the data collection period were available for carcass dissection. Only carcasses that were free of blemishes, trim loss, or that were not condemned and that were properly split were used in the study.

The average fat, skin, bone, and lean weight for each primal were calculated using a model that accounts for collection date and hot carcass weight. The LSMEANS are based on models developed for each individual USDA cull sow MWC. Similarly, the percent lean and fat by carcass and total live body weight for each primal cut by USDA cull sow MWC were calculated.

Because actual carcass lean content based on fat and muscle components was measured, backfat and loin muscle area were utilized to develop lean equations similar to what is commonly used to calculate percent carcass lean content in most market hog buying programs (Schroeder, Mintert, & Berg, 2004). In order to develop equations, a stepwise regression analysis and the maximum R option was utilized to determine the optimum components to include in the final carcass lean prediction equation (SAS Institute Inc., Cary, NC). The maximum R option was used to maximize the equation's predictive ability by adding fixed effects to the model in order of increasing variation explained by the effect. Fixed effects included hot carcass weight, backfat, and loin muscle area. Equations were derived for carcass and ultrasound measurements. Ten models were developed, four using data from the USDA cull sow MWC individually as well as an overall equation using data from all sows ($n = 176$) for both the carcass and ultrasound measurements. The R^2 values were obtained to determine the knife-separable lean content variation that was explained by each equation. Percent lean was predicted by using the intercept and slopes from the model for lean mass content to determine the expected lean mass and dividing it by hot carcass weight.

To validate the overall prediction equation with the ultrasound measurements, 5 data points were simulated for each market weight class (simulated data totaled 20 cull sow carcasses). Equal sample sizes across weight classes were used in order to evaluate the prediction equation effectiveness across all USDA cull sow MWC. Live weights within each USDA cull sow MWC were simulated from a normal distribution with mean and variance equal to the average live weight and standard deviation within each class. Hot carcass weight, backfat, and lean mass content were estimated using the correlation with live weight within each USDA cull sow MWC. The simulated lean content values were not generated using hot carcass weight, backfat, or loin muscle area information. Cull sow carcass predicted lean based on the simulated hot carcass weight and backfat measurements was estimated using the overall prediction equation for ultrasound measurement developed in this study. The correlation between the simulated lean content and the predicted lean content was calculated to determine how well the prediction equation estimated the lean content across USDA cull sow MWC.

3. Results

Table 1 shows the mean (±SD) live and hot carcass weights as well as ultrasonic and carcass backfat and loin muscle area by MWC. The hot carcass weight, backfat, and loin muscle area increased with greater cull sow MWC; however, the variances did not change with the heavier USDA cull sow MWC. The carcass measurements are greater than the ultrasonic measures due to technician bias (the

Table 1
Live weight, backfat and loin muscle area means (±standard deviations) from carcasses used in analyses of study of knife separable lean, fat, bone and skin weight by USDA cull sow weight class.

MWC[a]	1	2	3	4
LW (kg)	177.1 (±23.7)	216.1 (±12.3)	238.5 (±16.2)	276.7 (±23.0)
HCW (kg)	116.7 (±16.9)	143.1 (±10.0)	162.5 (±15.2)	189.2 (±17.0)
UBF (cm)	0.95 (±0.41)	1.03 (±0.23)	1.13 (±0.36)	1.62 (±0.46)
ULMA (cm^2)	36.37 (±6.13)	42.85 (±4.77)	45.46 (±7.74)	47.53 (±5.81)
CBF (cm)	1.67 (±1.12)	2.05 (±0.86)	3.18 (±2.16)	4.45 (±1.63)
CLMA (cm^2)	49.68 (±7.29)	57.06 (±9.74)	60.15 (±11.55)	62.39 (±7.94)
Yield (%)[b]	0.68 (±0.001)	0.67 (±0.000)	0.69 (±0.001)	0.69 (±0.002)
N	67	38	34	37

USDA cull sow market weight classes are based on the following live weight classes live weight class 1: 136.1 to 204.1 kg, class 2: 204.2 to 226.8 kg, class 3: 226.9 to 249.5 kg, and class 4: 249.6 kg and greater. Primal cuts were weighed using a 200 pound capacity Weigh Tronix Model 3275 (Fairmont, MN). Live weights were measured on a Ferguson–Hanks Corp Model 1200 B scale (Chicago, IL). Carcass weights were taken on a Weigh Tronix Model W I 125 digital rail scale (Fairmont, MN). Carcasses did not include head or feet. Carcass measurements were taken at approximately the 10th rib. Ultrasonic measurements were taken at approximately the tenth rib using an Aloka 500 V Real Time ultrasound machine (Corometrics Medical Systems, Wallingford, CT).
The mean was calculated using the formula:

$$E(HCW/LW) = (E(HCW)/E(LW)) + \left(Cov(HCW,\ LW)E^2(LW)\right) + \left(Var(LW)E(HCW)/E^3(LW)\right).$$

The variance was calculated using the following formula: $Var(HCW/LW) = (E^2(HCW)/E^2(LW)) * [(Var(HCW)/E^2(HCW)) - (2(Cov(HCW,\ LW)/(E(HCW)E(LW))) + (Var(LW)/E^2(LW))]$.

[a] MWC = USDA market weight class, LW = live weight, HCW = hot carcass weight, UBF = ultrasonic backfat, ULMA = ultrasonic loin muscle area, CBF = carcass backfat, CLMA = carcass loin muscle area.

[b] Yield is a ratio (hot carcass weight/live weight).