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PREDICTING BEEF QUARTER AND PRIMAL LEAN CONTENT USING ELECTROMAGNETIC SCANNING OF A HOMOGENEOUS POPULATION

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INTRODUCTION

Development of an instrument capable of grading beef carcasses and cuts on the basis of yield is an objective of the U.S. meat and livestock industries. Such an instrument for a commercial setting should be fast, accurate, non-invasive and reliable. Electromagnetic scanning (EMS) is a technology that was first used to estimate the composition of live pigs (Domermuth *et al.*, 1976). Further improvement in the sensing technology of EMS has resulted in strong relationships between EMS and predicted total body water (r=0.87, Presta *et al.*, 1983; r=0.99, Cochran *et al.*, 1988) and with fat-free mass (r=0.99) in human subjects (Fiorotto *et al.*, 1987).

Electromagnetic scanning is very effective in predicting the amount of lean in pork carcasses (Forrest *et al.*, 1989). Limited work has been done with beef carcasses or cuts. Lin *et al.* (1992) showed that the conductivity index of EMS is more important than weight when predicting lean quantity in large beef cuts such as quarters, rounds and chucks. Electromagnetic scanning can account for 85 to 92% of the variation in lean content of beef quarters, rounds, chucks and loins in a diverse population of steers and heifers (Gwartney *et al.*, 1992).

It appears that current EMS technology is available to objectively assess composition of beef carcasses and cuts which could pave the way for implementation of a value-based marketing system. Further research is needed to determine the ability of EMS to differentiate in yield among beef cuts from a homogeneous population. The objective of this study was to determine if EMS is effective in predicting lean content of beef quarters and primals from a homogeneous population of steer carcasses.

MATERIALS AND METHODS

One-hundred and twenty beef carcasses selected over a two year period (n=61, year one; n=59, year two) representing a homogeneous population in live weight and muscling were evaluated. Year one carcasses are characterized in Table 1. Year two carcass traits were similar to year one. Carcasses were evaluated for their lean content by scanning quarters and primals, after chilling, using EMS. Quality and yield grade data were obtained (USDA, 1985) prior to shipment of the right hindquarters (HQ) and forequarters (FQ) from a packing plant to the University of Nebraska Meat Laboratory.

Due to size limitations of the EMS unit, the brisket, foreshank and a portion of the plate were removed from the FQ prior to scanning. Length, internal temperature and weight were recorded on the right HQ and FQ prior to scanning in duplicate, posterior to anterior. Two electromagnetic scanning (EMS) units were utilized in this study with the MQ-25 model used in year one and the MQ-27 used in year two. These EMS units are manufactured by Meat Quality, Incorporated (Springfield, IL). The EMS units were calibrated to record 40 readings per second and belt speed was adjusted so cuts were scanned in approximately four seconds. The EMS unit contains a coil, lined with a rugged plastic tube measuring 66cm in diameter and 213cm in length, through which cuts are scanned. After scanning the HQ and FQ, quarters were fabricated into the primal round (IMPS 158), loin (IMPS 172), chuck (IMPS 113), rib (IMPS 103), the flank and dorsal portion of the plate (USDA, 1988). The primal round, loin, rib and chuck were scanned in duplicate, posterior to anterior, with length and weight being recorded prior to each scan. Each primal was dissected into lean (free of fat), bone (and heavy connective tissue), intermuscular fat and subcutaneous fat.

Statistical analyses included linear regression using the Statistical Analysis System (SAS, 1986). The dependent variables included total dissectable lean (kg) and percentage dissectable lean for the HQ, FQ and the four primals. Independent variables included quarter and primal weight, length, temperature, fat thickness determined at 3/4 of the length of the transverse section of the exposed *longissimus* muscle at the 12^{th} rib and the scan peak for each cut. The best four variable prediction models were evaluated and are presented in tabular form for each quarter and primal as coefficients of determination (CD) and residual standard deviations (RSD).

RESULTS AND DISCUSSION

Electromagnetic scanning technology is based on a low strength electromagnetic field operating at 2.5Mhz. Metals, which are highly conductive, absorb little energy while fat and bone are highly resistive and also absorb little energy. Lean mass, which is somewhat conductive, will result in greater impedance of the electromagnetic field (20 times greater than fat or bone) and thus a measurement of lean content is possible. A potential advantage of this technology is the direct indication of lean content, relatively free from biases of different breed or genotype (Gu *et al.*, 1992).

Table 2 contains results from year one for the best four variable models predicting quarter and primal lean content and percentage. For every dependent variable, the peak scan, 3/4 fat depth at the 12^{th} rib and weight of the cut being scanned were included in the predictive model with temperature and length being interchangeable as the fourth variable. The CD represents the amount of variation explained by the best model obtained from scanning and the RSD indicates the standard deviation of the predicted value.

In year one, 91% of the variation in dissected lean weight was accounted for when scanning quarters. Primal lean content was also highly predictable with CD ranging from 81 to 93% for the rib and chuck, respectively. Predicting percentage lean in the quarters or primals resulted in lower CD. Quarter lean percentage CD were 81 and 77% for the HQ and FQ respectively with RSD less than 1.7%. Coefficients of determination for the primals ranged from 61% for the round to 78% for the loin. Almost all of these results for percentage lean prediction meet the criteria adopted by the Commission of the EC for precision for an objective classification system (64% of the variation in percentage lean explained) and an accuracy of 2.5% (Walstra, 1990).

Since EMS measures the amount of lean and is little influenced by fat, predicting percentage lean content accounts for less variation than the prediction of dissected lean weight. Quarters or primals having the same amount of lean but different amounts of fat would yield different percentages of lean. Predicting dissectable lean weight resulted in equal or better results for year two and RSD were lower, indicating more accurate results (Table 3). Up to 94% of the variation in lean weight was explained for the HQ and 89 to 94% for its primals while 92 to 93% of the variation was explained for the FQ and its primals. Predicting percentage lean again resulted in lower CD than predicting lean weight. In year two, CD for predicting percentage lean were slightly, but consistently lower when compared to year one. For a homogeneous population of carcasses, it appears that EMS is effective in predicting subtle differences in lean content on a consistent basis.

CONCLUSIONS

Electromagnetic scanning is an advanced technology that meets many of the requirements for use in a value-based marketing system for beef quarters and primal cuts. It appears that EMS is effective on a homogeneous population of beef carcasses.

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Table 1. Carcass characteristics for year one.

Trait	Mean	N	Std Dev.	CV[1]
Carcass wt, kg	307.63	62	37.78	12.28
3/4 fat, cm	1.15	62	0.44	38.33
KPH, %	1.87	62	0.46	24.59
Ribeye area, cm^2	75.63	62	8.00	10.57
Marbling score [1]	323.0	62	88.30	27.29

[1] CV = coefficient of variation.
[2] 300 = SMALL^{00}.

Table 2. Coefficients of determination for individual quarter and primal scans from year 1 (n=61).

	CD, kg[1]	RSD, kg[2]	CD, %	RSD, %
HQ	90.90	1.12	80.51	1.63
ROUND	92.53	0.59	62.08	1.71
LOIN	90.24	0.42	78.02	1.84
FQ	91.51	1.30	77.99	1.66
CHUCK	93.92	0.71	69.16	1.72
RIB	81.26	0.29	74.84	2.22

[1] CD = coefficient of determination.
[2] RSD = residual standard deviation of the predicted value.

Table 3. Coefficients of determination for individual quarter and primal scans from year 2 (n=59).

	CD, kg[1]	RSD, kg[2]	CD, %	RSD, %
HQ	94.79	1.00	78.53	1.48
ROUND	96.49	0.51	54.81	1.50
LOIN	89.39	0.51	68.45	2.21
FQ	93.16	1.33	64.19	1.63
CHUCK	93.43	0.81	55.64	2.03
RIB	92.13	0.24	67.90	1.87

[1] CD = coefficient of determination.
[2] RSD = residual standard deviation.