THE AUTOFOM AND CVT-2 FOR PREDICTING SALABLE MEAT YIELD IN PORK CARCASSES

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Background

In Canada, the introduction in 1968 of a value-based system involving carcass weight and a ruler measurement of backfat thickness for grading pork carcasses and further refinements during the 80's (reflectance probe grading and the introduction of muscle thickness) have had a dramatic impact on the Canadian pork industry (Fortin, 1989). With these light reflectance probes (measurements of fat thickness lateral to the mid-line and the addition of muscle thickness into the prediction equations) the level of accuracy and precision improved (RMSE: from 2.6 % for the ruler to 2.1-2.2 % for the reflectance probes). Concurrent to the Canadian industry efforts to improve current grading technologies and implement new ones (Fortin et al., 2003), similar efforts were undertaken in Europe and the US. From these efforts, a new generation of grading instruments were developed. Ultrasound instruments such as the AutoFom (SFK Technology A/S, Herlev, DK) and CVT-2 (AUS, Ithaca, NY, US) are now commercially available for grading pork carcasses.

Objectives

The objective of this study was to evaluate under Canadian conditions the next generation of grading instruments which have become commercially available since the introduction in Canada in 1986 of the light reflectance probes, namely: the AutoFom (SFK Technology A/S, Herlev, DK) and the CVT-2 (AUS, Ithaca, NY, US). In addition, the reflectance probe HGP2 (Hennessey Grading Systems Ltd, Auckland, NZ) was utilized as the baseline instrument.

Materials and methods

Traditionally, grading instruments have been evaluated on the basis of the accuracy and precision of their respective equation to predict lean yield (lean and yield being defined in numerous ways). Calibration of a given instrument was done on a sample of carcasses deemed representative of the population onto which the prediction equation was going to be applied. Statistical parameters such as RMSE (Root Mean Square Error) and R^2 were used to assess these equations. Based on these parameters, that instrument was then certified for use in a national grading system if it met certain standard performance criteria. The over-riding assumption being that these equations generated from a sample of carcasses deemed representative of the population would perform as well when applied to the general population of pigs. However, in most cases, that assumption was never verified.

Hence, in this study, two independent sets of carcasses were used to evaluate the ultrasound instruments: one data set (calibration data set) to calibrate the instruments and a second data set (validation data set) to validate the fore-mentioned calibration.

The calibration data set and the validation data set consisted of 194 and 72 carcasses, respectively (Table1). Sampling was stratified by fat thickness. The boundaries for the middle category were defined as the Canadian population mean ± 0.50 standard deviation.

Two ultrasound instruments (CVT-2 System [3.5 MHz, 125 mm scanning guide], AUS, Ithaca, NY, US; and AutoFom, SFK Technology A/S, Herlev, DK) were evaluated. The reflectance probe HGP2 (Hennessey Grading Systems Ltd, Auckland, NZ) was used as the baseline instrument. For each instrument, the same operator was used for the entire study. For the CVT-2 and AutoFom, the operators were trained by the respective suppliers. The following carcass measurements were recorded: **AutoFom**: scan of the carcass as per supplier's instructions, **CVT-2**: fat thickness (average of five measurements) and muscle (*m. longissimus*) depth (average of five measurements) measured over a distance of 125 mm near the last rib, 5 cm lateral to the exposed surface of the mid-line. The muscle depth was defined as the distance between the fat-muscle interface to ribs. **HGP2**: fat thickness and muscle (*m. longissimus*) depth, 7 cm lateral to the exposed surface of the mid-line between the 3rd and 4th last ribs.

The day following slaughter, the left side of the carcasses was dissected as per the cutting procedure described by Fortin et al. (2003). Salable meat yield was defined as: 100*{(lean in picnic, butt, loin, tenderloin and ham) + belly (skinless, trimmed) + side ribs} / weight of cold side.

For the calibration phase, the models for predicting salable meat yield for the HGP2 and CVT-2 were obtained by Multiple Linear Regression analysis (Statistical Analysis System version 8.2, SAS Institute, Cary, NC, USA). The AutoFom calibration model was generated by Partial Least Squares analysis in which variables selection was done using a cross-validation procedure with 20 groups of 9-10 carcasses. The software program UNSCRAMBLER 7.6 (Camo, Trondheim, Norway), was used to generate the AutoFom calibration model.

For the validation of the calibration models, the following parameters were examined: 1) systematic bias defined as $Bias_s$ = 3(⌠ - Y_m) / n where ⌠ is salable meat yield predicted by the calibration model, Y_m the salable meat yield determined by the actual cutout of the side and n the number of carcasses, 2) proportional bias defined as $Bias_p$ = 1- b where b is the slope of the linear regression of predicted salable meat yield (⌠) on measured salable meat yield (Y_m) [⌠ = a + bY_m], 3) the Mean Squared Prediction Error ($MSPE_V$ = 3(⌠ - $Y_m)^2$ / n) and 4) and the Standard Error of Prediction (SEP_V = {3(⌠ - $Y_m)^2$ / (n–1)}^{½}).

Results and discussion

In Table 2 are the measurements obtained from the various grading instruments under investigation. For the AutoFom, however, the values of the fat and muscle measurements derived from the processed scan images and then used to generate the calibration models were not provided by the manufacturer. For the HGP2 and CVT-2, the following calibration model for predicting salable meat yield was selected:

Salable Meat Yield = a+ b*(fat thickness) + c*(muscle depth).

A recent Canadian study (Pomar et al., 2001) also showed that a linear calibration model for predicting yield was adequate. The calibration model for the AutoFom, provided by SFK Technology A/S, DK, is comprised of 36 variables (27 fat thickness and 9 muscle depth measurements).

The calibration parameters R^2 and RMSE assigned to each prediction model associated with the HGP2, CVT-2 and AutoFom are shown in Table 3. The CVT-2 prediction model compared favourably with the HGP2; RMSE: 1.57 % vs. 1.56 %, respectively, but was slightly better than the equation proposed for AutoFom; RMSE: 1.68 %. For each of the three instruments, all measurements retained for inclusion into their respective models were recorded over the loin muscle region: HGP2, CVT-2 and AutoFom. Consequently, it might then be argued that the high correlation between fat thickness measurements over the loin region or between muscle depth measurements over the loin region completely negated the advantage of using several variables, albeit statistically significant, over and above one fat thickness measurement and one muscle depth measurement over the loin region.

In Table 4, the validation parameters for the prediction of salable meat yield for the HGP2, CVT-2 and AutoFom are presented. For all instruments, the $bias_p$ was significantly different from zero ($P<0.01$). The AutoFom exhibited a slightly more pronounced $bias_p$ (0.39) compared to the CVT-2 (0.21); the HGP2 was intermediate (0.30). Figure 1 illustrates the respective relationship between Predicted salable meat yield and measured salable meat yield. With respect to a perfect theoretical relationship (solid line) of "Predicted salable meat yield vs Measured salable meat yield" (Y = a + bX where a = 0, b = 1, $bias_p$ = 0, and R^2 = 1) the fitted relationship (broken line) attests to an overestimation of the predicted salable meat yield for low measured salable meat yields (fat carcasses) and to an underestimation of the predicted salable meat yield for high measured salable meat yields (lean carcasses). Although a proportional bias was detected, no systematic bias ($bias_s$; $P>0.05$) was detected for all three instruments (Table 4). Standard Error of Prediction (SEP_V), another indicator of how well a prediction equation performs, was the lowest for the CVT-2 (SEP_V: 1.621), the highest for the AutoFom (SEP_V: 2.052) and intermediate for the HGP2 (SEP_V: 1.833). Insofar as for the prediction of salable meat yield, the validation procedure revealed a slight advantage for the CVT-2 (a less pronounced $bias_p$, no $bias_s$ and a lower SEP_V).

Conclusions

With the introduction in the early to mid-eighties of reflectance probe grading, the level of accuracy and precision in predicting yield, one of the key components of any grading systems, was dramatically improved. Since then, numerous attempts to improve accuracy and precision have been made: the development of ultrasound-based instruments being one of them. In this study, two ultrasound instruments, CVT-2 and AutoFom, were evaluated and compared with the reflectance probe HGP2, the probe traditionally used in Canadian studies as the baseline probe.

Calibration and validation procedures showed that, if one was to base the assessment of these ultrasound instruments strictly on the precision and accuracy for predicting salable meat yield, the improvement over the baseline reflectance probe HGP2 would be considered rather minimal, particularly for the AutoFom. However, the major advantage of these ultrasound instruments is that they are non-invasive. Furthermore, the AutoFom, being already fully automated and requiring minimal human intervention, can easily be integrated into the operation of a processing plant in order to fully use the information generated at the time of grading.

References

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Table 1. Number of carcasses: calibration data set and validation data set.

	Calibration data set (n=194)		Validation data set (n=72)	
Fat thickness [a]	Gilts	Barrows	Gilts	Barrows
Less than 17.3 mm	73	16	24	8
17.3-21.0 mm	25	40	12	13
Greater than 21.0 mm	11	29	4	11

[a] Fat thickness measured with the HGP2 (Hennessey Grading Systems Ltd, Auckland, NZ)

Table 2. Means and Standard Deviations of fat thickness and muscle depth for the Calibration data set and Validation data set.

	Calibration data set		Validation data set	
Variables	Mean	Standard deviation	Mean	Standard deviation
HGP2 [a]				
3/4 LR Fat thickness (mm)	17.93	3.79	1.10	4.23
3/4 LR Muscle depth (mm)	52.07	5.95	52.42	6.41
CVT-2 [b]				
Average fat thickness (mm)	18.70	4.46	19.06	5.36
Average muscle depth (mm)	57.04	5.35	57.41	5.40
Salable meat yield (%)	59.81	3.12	59.68	3.74
Warm carcass weight (kg)	59.81	3.12	59.68	3.74

[a] Hennessey Grading Systems Ltd, Auckland, NZ [b] AUS, Ithaca, NY, US

Table 3. Calibration parameters (R2 and RMSE) for the prediction of salable meat yield and AutoFom.

Grading Instrument	R^2	RMSE [d]
HGP2 [a] (Fat ** and Muscle **)	0.74	1.56
CVT-2 [b] (Average Fat ** and Average Muscle **)	0.75	1.57
AutoFom [c] (36 variable model)	0.75	1.68

[a] Hennessey Grading Systems Ltd, Auckland, NZ [b] AUS, Ithaca, NY, US [c] SFK Technology A/S, Herlev, DK [d] RMSE: Root mean square error. Variables in models for HGP2, CVT-2 and UltraFom 300: ** P<0.01, * P<0.05

Table 4. Validation parameters for the prediction of salable meat yield and the relationship of predicted salable meat yield (⌠) on measured salable meat yield (Ym): HGP2, CVT-2 and AutoFom.

			⌠ = a + b*Y_m				
Instrument	$Bias_s$ [d]	$Bias_p$ [d]	Intercept a	Slope b	SEP_V	$MSEP_V$	R^2
HGP2 [a]	-0.03(0.22[e]) NS	0.30 **	15.50 (2.901 [e])	0.70 (0.048 [e])	1.833	3.312	0.70
CVT-2 [b]	-0.01 (0.19) NS	0.21 **	12.71 (2.707)	0.79 (0.045)	1.621	2.590	0.79
AutoFom [c]	0.003 (0.24) NS	0.39 **	23.51 (2.798)	0.61 (0.047)	2.052	4.152	0.61

[a] Hennessey Grading Systems Ltd, Auckland, NZ b AUS, Ithaca, NY, US c SFK Technology A/S, Herlev, DK d NS P>0.5; ** P<0.01 e Standard error

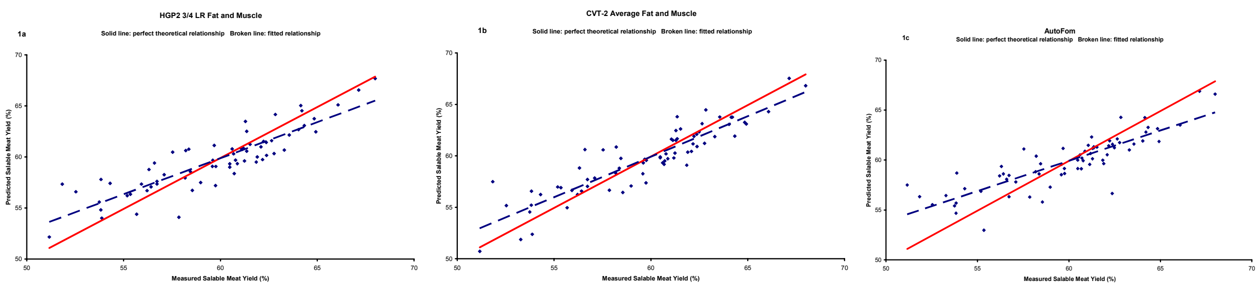

Figure 1. Validation of the HGP2, CVT-2 and AutoFom calibration models for predicting salable meat yield: relationship between predicted salable meat yield and measured salable meat yield.