EVALUATION OF THE COLORMET REFLECTANCE METER FOR THE MEASUREMENT OF PORK MUSCLE QUALITY

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INTRODUCTION

The inability to measure pork quality without first exposing a cut muscle surface has hindered discrimination against pork with poor lean quality and has been a serious deterrent to solution of problems relating to pale, soft, exudative (PSE) pork. Two types of portable meters have been tested for this purpose during recent years. The first involves the measure of deep-muscle reflectance with fibre optic technology (McDougall and Jones 1975, 1981). The second type of meter measures deep-muscle dielectric loss, conductivity or capacitance (Swatland, 1982; Kleibel et al, 1982).

A new and improved fibre optic reflectance meter has been developed by Swatland (1986, 1988) in conjunction with Metron Instruments Inc. of St. John's, Newfoundland. This instrument, which can be adapted to measure either surface or deep muscle reflectance, has not been adequately evaluated for its ability to predict pork quality traits.

Although the goal for these meters is the prediction of ultimate pork quality from measurements on the cold and the hot carcass, the present study was designed to compare and evaluate three portable meters (Colormet Fibre Optic Meter, McDougall Fibre Optic Probe, Techpro Quality Meter) with respect to their ability to predict muscle quality using post-rigor boned-out muscle.

MATERIALS AND METHODS

Boneless pork backs varying in quality from extremely PSE to moderately DFD (colour/structure scores of 1/1 to 4/4, Agriculture Canada 1984) were selected on the day following slaughter at a commercial packing plant (Fletchers Fine Foods Ltd., Red Deer, Alberta) and were transported to the Agriculture Canada Research Station, Lacombe for further testing.

At approximately 24 hour post-slaughter the longissimus dorsi (LD) muscle of each boneless back was divided into 2 sections of equal length. The colour and structure of the longitu[illegible] surface of both sections from each back w[illegible] evaluated subjectively by three experien[illegible] raters, according to the Agriculture Canada [illegible] Quality Standards (Agriculture Canada 19[illegible] Colour was rated on a 5 point scale, ranging [illegible] 1=extremely pale to 5=extremely dark. Struc[illegible] was rated on a 5 point scale, ranging [illegible] 1=extremely soft, exudative, dough-like, us[illegible] with open and grainy texture, to 5=extremely [illegible] dry, sticky, with closed and grainless texture. [illegible] 2 cm chops were marked for removal from [illegible] middle of each section. Two measurements w[illegible] conducted on each section within 2 cm of e[illegible] side of the designated pair of chops, usin[illegible] Chroma Meter II surface reflectance meter (Min[illegible] Canada Inc., Mississauga, Ontario) calibrated [illegible] standard white plate provided, a Colormet [illegible] optic reflectance meter (Metron Instruments In[illegible] St. John's, Nfld.) calibrated to a reading of 1[illegible] after covering the probe tip with 10 wraps [illegible] Teflon tape according to the manufactur[illegible] instructions, a British Fibre Optic Probe (F[illegible] McDougall and Jones 1981) calibrated using [illegible] Perspex Opal blocks, numbers 40 and 50, an[illegible] Techpro Quality Meter (QM; Des[illegible] Technologies Inc, Markham, Ontario).

The Colormet meter, which has been describe[illegible] detail by Swatland (1988), was powered by [illegible] VAC and was interfaced to a Tandy [illegible] microcomputer (Radio Shack, Barrie, Ontario) [illegible] all data collection.

A series of measurements was completed on [illegible] surface of one of each pair of chops beginning [illegible] least 15 minutes after the exposure of the c[illegible] surface. Subjective colour and structure sco[illegible] were evaluated as described above. At [illegible] locations for each chop surface reflectance w[illegible] measured with a Minolta Chroma Meter II and [illegible] was measured with a Fisher Accumet Model 6[illegible] pH meter fitted an Orion spear-type pH electro[illegible] The remaining chop from each pair was used [illegible] the determination of drip loss. Drip loss w[illegible] measured on the remaining chop from each pa[illegible] the amount of purge resulting during the stor[illegible] of the chop in a polyethylene bag for 48 hr at 2[illegible]

The remaining portion of each section was gro[illegible] 3 times through a #12 grinding plate for [illegible] measurement of expressible juice and pro[illegible] solubility. Expressible juice was determined [illegible] days after slaughter using a modification of [illegible] centrifuge method of Herring et al. (1971). It w[illegible] measured as the weight of supernatant a[illegible] centrifugation of 20 g of ground muscle at 37[illegible] xg for 15 min. Protein solubility was measu[illegible] according to the method of Barton-Gade (1984), except that the result was expressed as grams soluble protein per kg of lean muscle instead of as optical density.

Analysis of variance, regression analysis and discriminant analysis were conducted using standard procedures of SAS (1985).

RESULTS

LD muscles were chosen for this study only if their longitudinal surfaces were subjectively judged to be of uniform quality throughout their length. Even so, sample location affected both subjective and objective quality, as well as meter readings. Because these effects were small, sampling sites were averaged for all subsequent analyses.

Subjective muscle quality scores were of the colour and structure categories indicated in table 1, with the exception of the LD muscles from 3 pigs which had subjective colour/structure scores of 1/2 and 3/2. Colour/structure scores are characterized in terms of several other objective quality measures in table 1. Minolta meter Y values, drip loss and protein solubility were related to subjective assessments of quality. Although neither pH nor expressible juice distinguished well between colour/structure scores 1/1 to 2/2, both were related to subjective quality at greater colour and structure scores.

Means for three portable deep-muscle probe meters are also presented by subjective quality scores in table 1. Colormet meter Y values and FOP readings distinguished differences in subjective quality categories, the QM proved useful only at colour/structure scores greater than 2/2, and Colormet meter x and y values appeared to be of little value to distinguish between quality categories.

Discriminant analyses were conducted in order to determine which of the meters best differentiated between subjective quality scores. The frequencies of correct classification by the meters into the various subjective colour and structure categories is presented in Table 2. The Minolta meter was the most accurate for classifying by both subjective colour and structure. This was not surprising, in that Minolta meter measurements were conducted on the same surface that was used for subjective evaluations, while the other meters were inserted up to 5 cm from that surface. The Colormet meter and the FOP were quite similar in performance with the FOP slightly better related to colour scores and the Colormet meter slightly better related to structure scores. The QM was not as useful as the other meters for this purpose. The ability of the meters to predict subjective and objective quality measurements was investigated by regression analyses (Table 3). Inclusion of a quadratic term within the regression

Table 1. Means for muscle quality evaluations and test meter readings classified by colour/structure category (Agriculture Canada 1984).

Quality Trait	Colour/Structure Score						
	1/1	2/1	2/2	3/3	4/4	R^2	RMS
n	5	10	11	14	15		
Minolta Meter Y	30.3a	27.0ab	26.3b	18.0c	10.6d	0.94	1.90
Minolta Meter x	0.327a	0.327ab	0.325b	0.318c	0.311d	0.89	0.002
Minolta Meter y	0.354ab	0.360a	0.353b	0.345c	0.336d	0.65	0.007
pH - 24 hr	5.33a	5.43a	5.46a	5.63b	6.47c	0.85	0.19
Expressible Juice§	34.4a	32.4a	33.4a	26.5b	5.9c	0.90	3.96
Drip Loss§	5.0a	4.1ab	4.6b	2.3c	0.7d	0.73	0.98
Soluble Protein§	10.7a	11.3ab	11.9b	18.2c	20.5d	0.87	1.65
Colormet Meter Y	18.2a	17.5ab	16.8b	11.5c	7.0d	0.86	1.88
Colormet Meter x	0.298a	0.298a	0.295b	0.294c	0.294c	0.15	0.004
Colormet Meter y	0.324	0.323	0.321	0.320	0.322	0.08	0.004
Fiber Optic Probe	170.3a	164.4b	158.1b	132.8c	114.9d	0.87	8.28
Quality Meter	12.5a	12.8a	13.1a	10.1b	5.6c	0.76	1.82

R^2 - Coefficient of determination RMS - (error mean square)$^{0.5}$
§ - g/100g wet weight

Table 2. Discriminant analysis to show the frequency (%) of correct assignments of colour and struc scores (Agriculture Canada 1984) by several portable meters.

Meter	Subjective Colour					Subjective Structure				
	1	2	3	4	All	1	2	3	4	All
n	4	19	19	16	58	8	18	17	15	58
Minolta Y,x,y	100	89	84	94	90	50	72	88	100	81
Colormet Y,x,y	50	68	63	88	71	75	78	76	93	81
Fiber Optic Probe	25	68	68	100	74	38	72	71	93	72
Quality Meter	75	47	16	81	50	50	56	35	87	57

Table 3. Coefficients of determination (R^2) for the linear and quadratic regressions of several subjective an objective quality measures on meter readings.

Dependent Variables (Y)	Independent Variables (X)							
	Minolta Y		Colormet Y		FOP		QM	
	X	X+X2	X	X+X2	X	X+X2	X	X+X2
Subjective Colour§	0.93	0.93	0.81	0.84	0.82	0.84*	0.62	0.62
Subjective Structure§	0.92	0.92	0.85	0.88*	0.88	0.90*	0.70	0.70
pH	0.75	0.85*	0.65	0.81*	0.68	0.77*	0.66	0.71*
Drip Loss	0.68	0.68	0.53	0.64*	0.64	0.70*	0.63	0.63
Expressible Juice	0.81	0.88*	0.71	0.89*	0.72	0.88*	0.80	0.81
Soluble Protein	0.83	0.84*	0.87	0.88	0.89	0.89	0.68	0.69
Minolta Meter Y	-	-	0.91	0.94*	0.89	0.91*	0.72	0.72

§ Agriculture Canada (1984)
* The X^2 term was significant ($P<0.05$).

equations indicated that readings of three of the meters were related to other quality measures in a non-linear fashion. This was particularly true for pH, drip loss and expressible juice for which inclusion of a quadratic term in the equation resulted in an increase of up to 25% in the R^2 values. Both the Colormet meter and the FOP were very good predictors of subjective and objective quality measures. Either meter explained in excess of 80% of the variation in subjective quality scores, Minolta meter Y value, expressible juice and soluble protein, and somewhat less of the variation in pH and drip loss. Correlations were much higher than those presented by others (eg. Somers et al. 1985, Swatland 1988) because of the fact that LD muscles were chosen to have a very wide range of quality. Of the three meters tested, the Colormet meter Y value was the best predictor of surface reflectance and pH whereas the FOP was the best predictor of subjective structure and drip loss. The QM performed less satisfactorily than the other meters for the prediction of all subjec and objective quality traits.

The Colormet meter provided output reflectance values at 10 nm intervals between wavelengths of 400 and 700 nm. Figure presents reflectance spectra for each of subjective colour quality groups. Although reflectance values were determined with instrument calibrated to read 1000 after wrapp the probe with Teflon tape, transformation of values to an optically pure barium sulfate stand could have been applied according to approach described by Swatland (1988). T spectral pattern shows a major influence myoglobin (Hunt 1980). Colour categories 1 2 are not as well differentiated as the o categories. In order to determine if the reflec values had potential for the prediction of qu measures, regression analyses were comple with quality measures as dependant variables both reflectance values and their squares

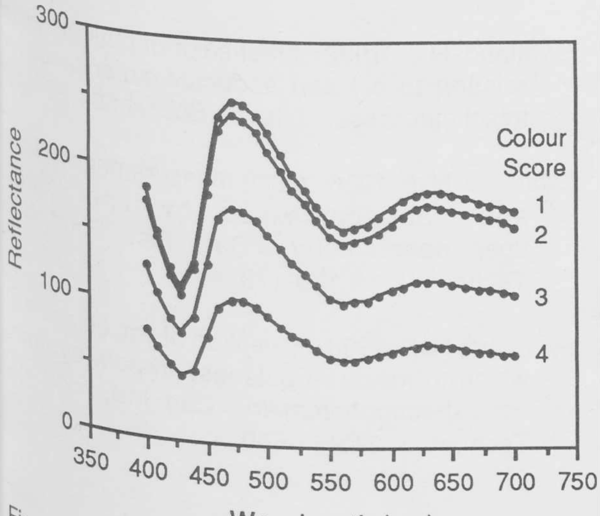

Figure 1. Colormet meter sprectral reflectance for the longissimus dorsi muscles with subjective colour scores (Agriculture Canada 1984) from 1 to 4.

independent variables. Coefficients of determination (R^2 values) are presented in Figure 2 for wavelengths between 400 and 700 nm. The predictability of quality traits by reflectance values was very dependant upon wavelength. Predictions were best at wavelengths in excess of 450 nm. For pH and expressible juice, predictions were best at approximately 470 nm, whereas for protein solubility predictions were more accurate at 700 nm. At the wavelengths specified these three traits gave R^2 values which were higher than those obtained from the Colormet meter Y values, indicating that the use of reflectance at

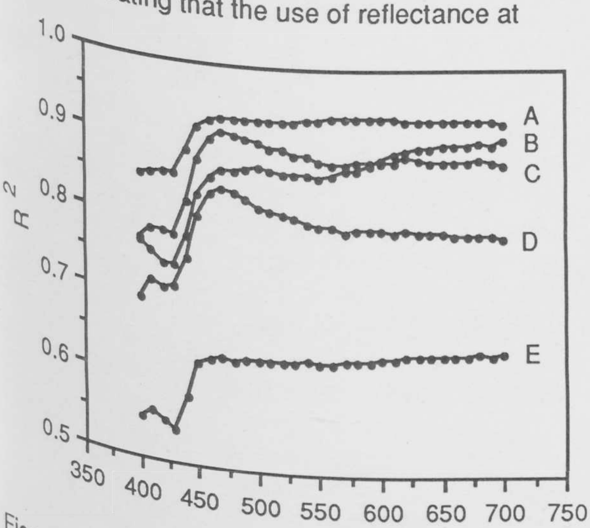

Figure 2. Coefficients of determination (R2) resulting from the regression of several quality traits (A - Minolta meter Y, B - soluble protein, C - expressible juice, D - pH, E - drip loss) on the reflectance plus the square of the reflectance at wavelengths between 400 and 700 nm.

specific wavelengths may have merit. Whereas reflectance at a particular wavelength could explain 80-90% of the variation in colour and structure scores, the reflectance ratio, 400/700 nm accounted for only 15 % of the variation. This is in contrast to the findings of Swatland (1988), who found that this ratio was useful for the prediction of subjective quality scores. Although it has not yet been tested, the use of reflectance at specific wavelengths may be useful for the estimation of muscle pigment concentrations.

CONCLUSIONS

The performance of the Colormet spectral reflectance meter has been evaluated 24 hr post-slaughter in comparison to two other deep-muscle meters (FOP and QM) for the prediction of several subjective and objective pork quality traits. Colormet meter Y values were of similar predictive value to the FOP meter readings and were superior to QM meter readings.

The Colormet meter provides not only Yxy and L*a*b* colour coordinates, but also spectral reflectance data over the 400-700 nm range. The use of reflectance values at specific wavelengths increases the predictive power of this meter, and additionally may offer a convenient means for quantitation of muscle pigment.

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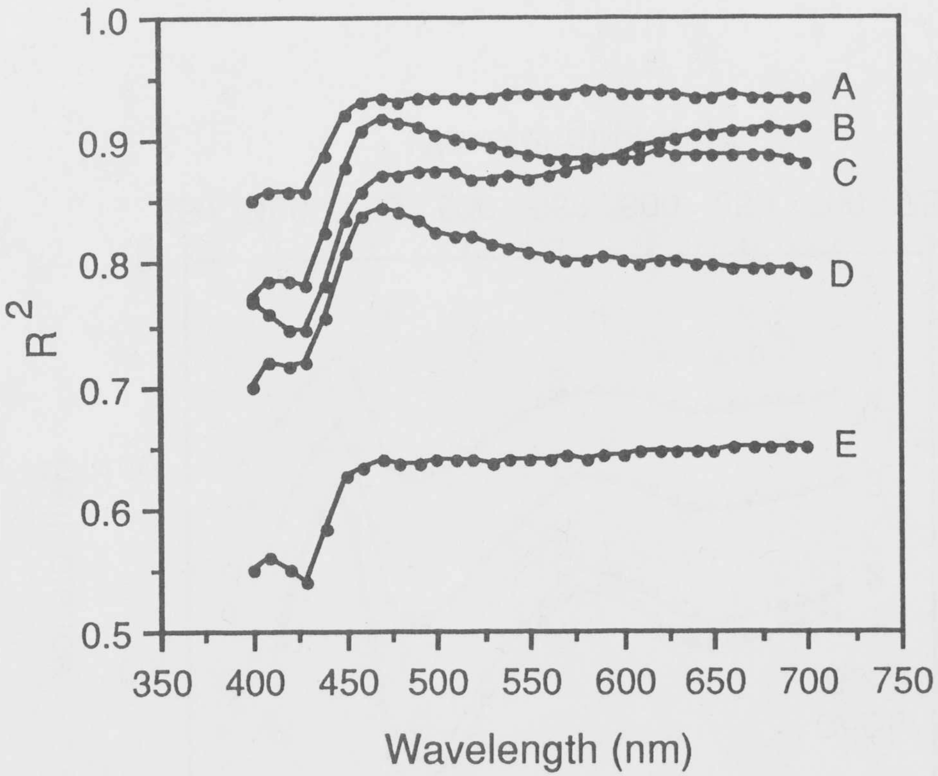
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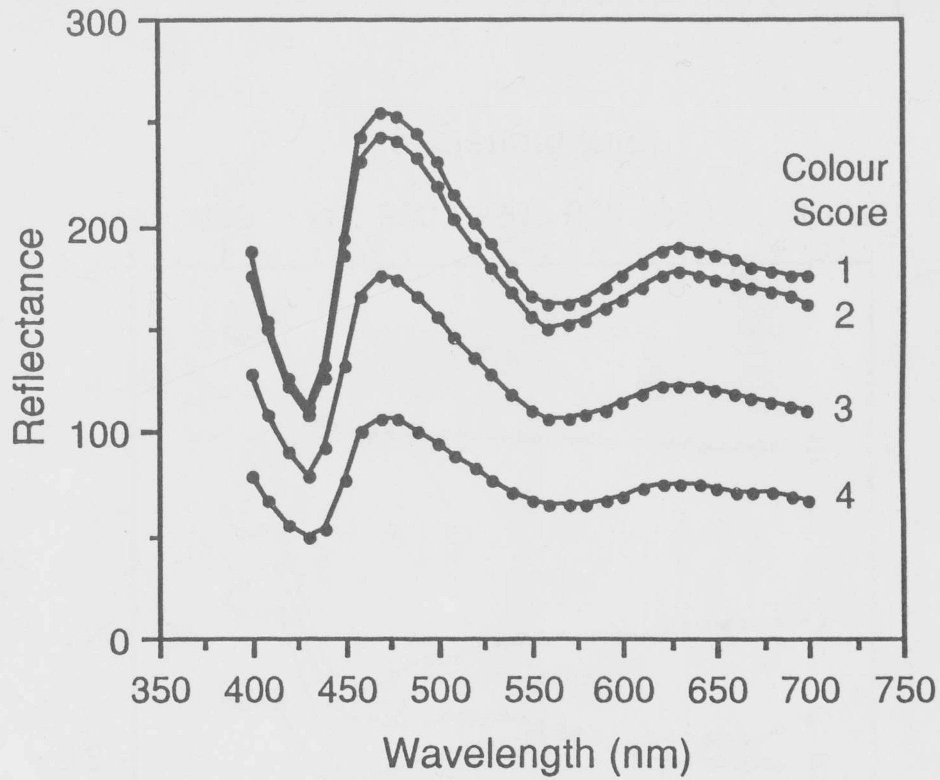
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