DIGITIZED IMAGE ANALYSIS FOR ASSESSMENT OF PORK QUALITY

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BACKGROUND

Although digitized-image analysis has been tested for its ability to measure the fat and lean content of beef muscles (Newman 1984: Unklesbay et al. 1986), it has not been tested extensively for use in pig muscles. The image analysis technique could prove useful for the segregation of certain wholesale cuts and muscles for export, for domestic sale or for further processing based on factors such as colour, surface texture, pigment content and fat content/distribution. This study is a preliminary assessment of the potential of digitized image analysis for the evaluation of pig muscle quality.

METHODS

Selection of Muscle Samples. Centre-cut pork chops (n=79), which had been on retail display for no more than 24 hr, were selected from major supermarket chains, so that the longissimus muscle was of a range of muscle subjective color (pale to dark) and subjective marbling types (devoid to extreme).

Capture and Analysis of Images. A Kodak Professional DCS 420 Digital Camera (24 bit color, 1524 x 1012 pixels) was mounted on a Kaiser RS2 copy stand equipped with electronic flash units in a dark room. The flash units were pointed toward a white ceiling. Chops were removed from the retail packages, and the surface of the longissimus muscle of each was scraped lightly to remove any residual fat or other particulate matter prior to photography. Images were imported into a Power Macintosh 8100/80 computer using a Kodak DCS-420 driver and Adobe Photoshop (Adobe Systems) software.

Within a representative portion of the image, measuring 500x300 pixels, the average level and standard deviation of grey, red, green and blue were obtained using Adobe Photoshop software. Additionally, thresholding was applied, so as to best distinguish the marbling features. The relative area of marbling, as well as the grey level (threshold) which distinguished marbling from non-marbling, were recorded.

Measurements of Lean Muscle Quality. At the time of photography, subjective color, structure and marbling were assessed and refectance and pH were measured on the surface of the longissimus muscle. Subjective colour and structure were evaluated according to the Agriculture Canada Pork Quality Standards (Agriculture Canada 1984). Colour was rated on a 5 point scale, ranging from 1=extremely pale to 5=extremely dark, and structure was rated on a 5 point scale, ranging from 1=extremely soft, exudative, dough-like, usually with open and grainy texture, to 5=extremely firm, dry, sticky, with closed and grainless texture. Marbling was measured subjectively using the 6 point scale (devoid, trace, slight, small, moderate, abundant) of Jones et al. (1992). The pH was measured with an Orion Model 290A pH meter fitted with an Orion spear-type combination electrode. Paleness (L*), chroma (C) and hue (H) were measured in triplicate using a Minolta CM-2002 spectral reflectance meter. Total pigment was assessed by the method of Trout (1991). Protein solubility, moisture content and fat content were measured as described by Murray and Jones (1994).

RESULTS AND DISCUSSION

In keeping with other research findings, pigment content, protein solubility and pH were lower, whereas L*, C and H were higher in paler chops. L* (paleness) was highly correlated (r=0.89) with protein solubility and was significantly, but less highly correlated ($r\approx0.70$), with pH and pigment. Intramuscular fat was correlated with moisture content (r=0.69) and less strongly correlated (r=0.56) with subjective marbling score. Neither chemical fat nor subjective marbling score was correlated highly ($r\leq0.34$) with L* or protein solubility, indicating that fat has very little effect on the ability of these traits to predict muscle quality.

Multiple regression analyses (Table 1) confirm the strong relationships between subjective color, subjective structure, L*, and protein solubility. Between 80 and 90% (i.e. R^2=0.80-0.90) of the variation in these traits, between 70 and 80% of the variation in pH and moisture and between 60 and 70% of the variation in pigment and fat content could be explained by the other quality traits. Yet only 43% of the variation in subjective marbling could be accounted for.

The image color traits were good indicators of objectively-measured color, accounting for 87% of the variation in L* value. These traits were slightly less capable of predicting subjective color (R^2=0.77), subjective structure (R^2=0.75) and protein solubility (R^2=0.77), and only explained approximately 50% of the variation in pH, pigment and fat. Even though a distinct positive relationship between marbling level and the standard deviation of the grey, red, green and blue levels was noted, this group of traits accounted for only 64% of the variation in subjective marbling score.

Discriminant analysis was applied to determine the ability of the various groups of image traits to categorize subjective color, structure and marbling. Image traits predicted subjective color and structure categories with error rates of 15%. This compared very favorably with the 14 and 7% error rates obtained using L* and protein solubility to predict subjective color and structure categories.

respectively. The objective quality measures and the image traits distinguished pale from normal pork with high accuracy (error rates of only 3-4%).

Table 1. Multiple regressions with pork quality traits as dependent variables and either pork quality traits or image traits as independent variables′.

Dependent Variable	Quality Traits	R^2	Image Traits	R^2
Subjective Color	L*	.87	Green Level	.64
	Prot. Sol.	.88	Threshold	.76
			Blue Level	.77
Subjective Structure	L*	.76	Green Level	.55
	Prot. Sol.	.81	Blue Level	.72
	Hue	.83	Red Level	.75
	Chem. Fat	.85		
Subjective Marbling	Fat	.22	%Marbling	.48
	Chroma	.39	Red Level	.56
	Prot. Sol.	.43	Blue_SD	.59
			Red_SD	.64
pH	Chroma	.62	Red Level	.39
	Hue	.72	Red_SD	.50
	Chem. Fat	.78		
Pigment	L*	.48	Green Level	.42
	Chroma	.63	Threshold	.52
	Hue	.65		
Prot. Sol.	L*	.79	Green Level	.59
	Marbling	.81	Threshold	.73
	Moisture	.82	%Marbling	.77
	Hue	.84		
	Chem. Fat	.85		
Moisture	Fat	.48	Green Level	.35
	Prot. Sol.	.68	%Marbling	.44
	pH	.72		
	L*	.73		
	Hue	.75		
Fat	Moisture	.48	%Marbling	.43
	Marbling	.66	Threshold	.52
L*	Prot. Sol.	.79	Green Level	.72
	Pigment	.84	Threshold	.83
	pH	.88	Blue Level	.85
	Fat	.91	Red Level	.87
Chroma	pH	.62	Red Level	.45
	Moisture	.71	Threshold	.49
	Pigment	.75		
	Prot. Sol.	.78		
	Fat	.80		
Hue	pH	.59	Green Level	.67
	Pigment	.73	Blue Level	.80
	Moisture	.79		
	Prot. Sol.	.80		

′ Variables yield a significant increase ($P \leq 0.05$) in R^2.

None of the objective quality traits or image traits could effectively segregate (error rates > 37%) marbling into its subjectively-determined categories. This is surprising, since both subjective and image measurement of marbling occurred within a few minutes on the same chop surface. Most likely there was a deficiency in the subjective scoring of marbling and not in the image thresholding process.

CONCLUSIONS

Although this particular approach to evaluation of pork quality from a digitized image requires further refinements, digitized image analysis does appear to offer potential for automated evaluation of the muscle quality of pork, and it provides a moderately good indication of visual marbling.

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