EVALUATION OF TECHNIQUES FOR MONITORING PORK QUALITY IN AUSTRALIAN PORK PROCESSING PLANTS.

GRAHAM R. TROUT, CSIRO Division of Food Processing, Meat Research Laboratory, Cannon Hill, 4170, Australia

SUMMARY

A study was carried out to evaluate the suitability of a range of techniques for evaluating pork quality when used on a routine basis in pork processing plants. The measurements were carried out at approximately weekly intervals in one of four different abattoirs over a twelve month period. Loins were randomly selected at each plant and quality attributes were objectively evaluated using the following techniques: Minolta Chroma Meter, Colormet probe, fibre optic probe (FOP), visual colour and texture scoring, pH, protein solubility, filter paper water-holding capacity, and high speed centrifugation water-holding capacity. Quality was assessed by measuring 48-hour drip loss and the yield of cured cooked product. Using these two quality measures and sample pH, an index was developed that classified the pork into five quality groups: Extremely DFD (dark firm and dry).....Extremely PSE (pale soft and exudative). The results were statistical analysed was then carried out on the data to determine how effectively each of the objective techniques separated the pork into the five different quality categories. Of the techniques evaluated, the Minolta Chroma Meter L and b values, Colormet L value and FOP could be used to separate the samples into the five quality groups ($p < 0.01$).

INTRODUCTION

Post-rigor porcine muscle varies considerably in its ability to hold water during storage, processing, transit and retail display. This is because porcine muscle is very prone to two conditions that affect its water holding ability: PSE (pale soft and exudative) and DFD (dark firm and dry). These two conditions represent the extremes of the water holding ability in post-rigor muscle. The incidence of these conditions are influenced by variables as diverse as genetics, anatomical location of the muscle, preslaughter treatment, stunning methods and postslaughter cooling rate.

In Australia, the incidence of PSE and DFD in pork is high and very variable. Our recent survey of the quality of pork in five major abattoirs showed that over a twelve month period the average incidence of PSE and DFD was 32 and 15%, respectively: the incidence of PSE varied from 5%-65% and DFD from 0%-45% (Trout et al., 1991).

Because of this extreme variation in pork quality, the Australian pork processing industry is interested in accurate and rapid techniques for evaluating quality. Although many techniques have been developed to evaluate pork quality (Kauffman et. al., 1986a) most of these techniques have not been evaluated and compared in abattoir environments. Moreover, with most techniques it has not been determined if they give similar results when used in different abattoirs or whether the techniques are robust enough to be able to give consistent results over a period of time when used by different operators.

Hence, the objective of this study was to evaluate the suitability of a range of techniques for evaluating pork quality when used on a routine basis in pork processing plants.

MATERIALS AND METHODS.

Sample collection and description of techniques. Pork loins were selected randomly from one of four abattoirs at approximately weekly intervals; 792 loins were collected during the course of the study. On each collection day, twenty four loins were selected from one of four plants over a period of four hours so as to obtain a representative sample of the previous days kill.

In the abattoirs, the loins were cut approximately 20 cm from the anterior end. The 20 cm section of loin removed was the portion that extended between the 4/5th rib and the 11/12th rib. The filter paper WHC test of Kauffman et al. (1986b) was carried out on both cut surfaces using a 5.5cm S&S 589³ filter paper on one surface and a 5.5cm Whatman No 3 on the other. The time between cutting and assessing WHC was reduced to 5.0 minutes as this had previously been shown to give more reproducible results (Trout, 1992).

After all samples had been collected, they were transported (30-180 min) in refrigerated insulated containers to a refrigerated room (10°C) where they were evaluated. Probe measurements were taken immediately on all loins using the Colormet probe (Instrumar Engineering Ltd.,St.Johns', NF, Canada) and fibre optic probe (FOP) (Integrated Electro Optics, Barnsley, England). All fat, connective tissue, and overlying muscles were removed from the loin; the denuded *l. dorsi* (longissimus. dorsi) muscle was used for the all subsequent testing. Immediately after trimming, the filter paper WHC test was carried out on a freshly cut surface on the posterior end of the sample

using the unmodified procedure of Kauffman et al. (1986b). The loins were evaluated for colour and firmness by six trained assesso using an 8 point scale (1=extremely pale.....8=extremely dark; 1 = extremely soft.....8 = extremely firm). Measurements were mad on both ends of the loins with the following instruments: 1) Minolta Chroma Meter (Illuminant D65, 2° observer angle, CIE L,a,b [Minol Camera Co. Ltd., Osaka, Japan]), 2) FOP, and 3) pH meter (HI 8424 Meter, Hanna Instruments SpA, Limena, Italy; in conjunction wi a Phillips C64-1 Combination Glass Electrode, Phillips, South Australia). Samples were taken progressively from the posterior end the loin for 1) drip loss (Honikel et al., 1985) 2), protein solubility (sample to buffer ratio 1:10; 0.04M pH 6.5 phosphate buffer modification of the procedure of Lopez-Bote et al., 1989]), 3) pigment concentration (Trout, 1991), 4) high speed centrifugation WH (Bouton et al.,1971) and 5) cure uptake and cured loss.

Cure uptake and yield was carried using a weighed 100 $\pm$ 1 g sample. The sample was injected with 15% of its weight of bri using a 18g needle and 30ml syringe (final sample concentration 2.2% salt, 0.5% sodium tripolyphosphate, 135ppm sodium nitrite, 0.03 sodium erothorbate, and 0.54% sugar), vacuum packed and stored at 5°C for 73 hours. After 73 hours storage, the samples were remove from vacuum bags, reweighed, placed in polyethylene bags, heated to 70°C for 60 minutes, cooled in running tap water for 30 minute removed from the bags, patted dry with paper towel and reweighed. Cure uptake was calculated from the initial sample weight and t weight before cooking. The cured yield was calculated from the initial sample weight and the weight after cooking.

Assessment of techniques. To evaluate the effectiveness of each technique, an index was developed using 48-hour drip loss, cured lo (100 - cure yield) and ultimate pH to classify the pork into five quality groups: Extremely DFD (dark firm and dry).....Extremely PSE (pa soft and exudative). The criteria used for each quality group was as follows:

1. Extremely DFD	Ultimate pH > 6.5
2. DFD	6.0 < Ultimate pH < 6.5
3. Normal	Ultimate pH < 5.9 and (drip loss + cured loss) < 7.0%
4. PSE	Ultimate pH < 5.9 and (7.0% < [drip loss + cured loss] < 14.0%)
5. Extremely PSE	Ultimate pH < 5.9 and (drip loss + cured loss) > 14.0%

Statistical Analysis. All samples collected, regardless of date of collection or abattoir from which they were collected, were allocat to one of the five quality categories using the criteria described above. The mean values for each technique evaluated were determin for each quality group. The resulting values were analysed by analysis of variance using a completely randomised design with uneq treatment numbers. Fischer's Least Significant Difference test was used ($p < 0.01$) to determine difference between treatment mea

RESULTS AND DISCUSSION

In previous studies in this area, drip loss has been used as an indicator of the extent of PSE in pork. However, this approach not completely satisfactory since other factors such as postmortem muscle shortening can result in pork muscle having greater drip lo than normal (non-PSE) muscle (Honikel et al., 1986). Consequently, if drip loss is used as the selection criterion, normal (nonPSE) po muscle that has cold shortened can be incorrectly classified as PSE. To overcome this problem in this study, an index was develop which is the sum of the drip loss and cured loss. This approach was used because both of these losses are economic losses and both a directly related to the extent of PSE in the muscle.

Colour and texture scores. Analysis of the data (Table 1) showed that neither colour nor texture score could be used to separate t pork samples into the five quality categories ($p > 0.01$). Colour score could be used to distinguish between Extremely DFD, DFD a Normal pork but not between Normal and PSE. Moreover, the mean colour scores of 4.4 for PSE and 3.6 for Extremely PSE were qu high and, according to the descriptors used by the evaluators, would correspond to pork colours of 'Normal' and between 'Sightly Pa and 'Moderately Pale', respectively. These results reinforce the findings of Kauffman et al. (1992) who found that many pork samp that have low WHC have normal colour. Texture scores were even less effective than the colour scores in separating the pork into t five quality categories.

Tristimulus L,a,b values. The objective measures of colour in this study (the Minolta Chroma meter values for surface colo measurement and the Colormet probe for internal colour measurement) were both effective at segregating the pork samples into the f

quality categories (Table 1). With the Minolta readings, both L and b values could be used to categorise the samples ($p<0.01$); however, with the Colormet probe only the L values were effective ($p<0.01$).

The results obtained with the devices for the objective measurement of colour appear to contradict those obtained with the subjective scoring, in that the objective techniques could discriminate between the five quality groups while subjective scoring could not. However, these two sets of results are not necessarily contradictory since the subjective scoring is measuring perceived colour differences and the objective colour meters measure light scattering. Although the objective devices are designed to measure colour, in situations were the pigment concentration does not vary (such as in this study [Table 1]) the devices actually measure light scattering. This is because the perceived colour of meat is a function of the light scattered and light absorbed. At constant pigment concentration the variation in colour is due to variation in light scattering. This conclusion is supported by the fact that the Minolta L value is more highly correlated ($r=0.97$) with the FOP values (which measures light scattering), than it is with visual colour score ($r=-0.71$).

FOP - Fat on and Fat off. Both FOP measurements, fat-on as an internal muscle measurement and fat-off as a surface measurement, could be used to categorise the pork into the five quality groups. As has been shown before (MacDougall, 1970) devices such as this that measure light scattering at wavelengths not affected by pigment absorbance (in this case in the near infrared) are effective for evaluating pork quality.

One difference between the fat-on and fat-off measurements was that the fat-off values were higher than the fat-on values for the PSE and Extremely PSE categories. A possible reason for this is that with the denuded muscle (i.e., the fat-off sample) some of the light travels through the sample and dissipates; as a result less light is reflected back to the device and the resulting FOP reading are lower.

A point to note with the values obtained with the FOP is that they are relative and not absolute values. It was found in earlier studies that the FOP values obtained with a particular sample depended on the model of the instrument used, the brand of the instrument used and the calibration blocks used for calibrating the instruments. However, the values obtained with one instrument were highly correlated with another provided that the same calibration blocks were used with both instruments. This between instrument variation with the FOP is a major problem with setting pass/fail limits for each quality group.

WHC - Filter paper. All three of the filter paper WHC techniques could allow differentiation between Normal, PSE and Extremely PSE samples ($p<0.01$). None of the three filter paper techniques could, however, differentiate between the Extremely DFD and DFD samples. The reason for this being that there was little difference in WHC between the Extremely DFD and the DFD samples. There were bigger differences between the mean values for the Normal, PSE and Extremely PSE categories with the Whatman No 3 filter paper than with the other two filter papers techniques. However, there was also a similar increase in the s.e.d, hence the use of the Whatman No 3 filter paper had no advantage over either of the methods using the S&S filter papers.

The purpose of using three different filter paper methods was to overcome deficiencies in the original method of Kauffman et al. (1986b). With their original method, the procedure was used in a laboratory with a holding time between cutting and measuring of 15 minutes. The problems with this method are that the S&S 589[3] filter paper can not absorb all drip released during that time (particularly from Extremely PSE samples) and the method is too slow to use in a processing plant. To overcome these problems, the time was reduced to 5 minutes in both modifications and the Whatman No 3 filter paper (a thick absorbent filter paper) was used in one of the methods. The results from this study indicate that there is little difference between the three methods. A subsequent study has shown that the use of the S&S 589[3] and 5.0 minutes between cutting and measuring gives results which are more reproducible and more highly and linearly correlated with drip loss ($r=0.994$) than the other two methods (Trout, 1992).

WHC - high speed centrifugation. WHC determined by high speed centrifugation could not differentiate between the PSE and Extremely PSE samples ($p>0.01$) and hence is not a procedure recommended for evaluating pork quality.

Protein solubility. The protein solubility method, although not effective at differentiating between Extremely DFD and DFD pork, could differentiate between the other four categories. This method does, however, have a relatively high s.e.d. indicating the results obtained with it would be much more variable than the methods previously described that can differentiate between the Normal, PSE and Extremely PSE quality groups.

CONCLUSION

Of the techniques evaluated, the Minolta Chroma Meter L and b values, Colormet L value and FOP could be used to separ the samples into the five quality groups ($p < 0.01$). Protein solubility could be used to differentiate between Normal and PSE and P and Extremely PSE pork; hence in combination with pH measurements it could be used to differentiate between the five categorie

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Table 1. The mean values of each method evaluated for the five pork quality types.

TECHNIQUE	EXTREMELY DFD n = 28	DFD n = 95	NORMAL n = 460	PSE n = 122	EXTREMELY PSE n = 87	[1]s.e.d.
Colour Score	6.9[a]	6.0[b]	4.9[c]	4.4[c]	3.6[d]	0.16
Texture Score	5.2[a]	5.4[a]	4.4[b]	4.1[b]	3.5[c]	0.22
Minolta L	37.8[a]	42.3[b]	47.7[c]	51.6[d]	55.5[e]	0.63
Minolta a	6.9[a]	6.7[a]	7.4[a]	8.0[b]	9.1[c]	0.26
Minolta b	-1.1[a]	-0.3[b]	1.4[c]	2.7[d]	4.5[e]	0.26
Colormet L	22.1[a]	25.1[b]	28.4[c]	31.3[d]	35.0[e]	0.73
Colormet a	-3.4[a]	-3.6[a]	-3.8[a]	-3.8[a]	-3.8[a]	0.25
Colormet b	-0.3[a]	-0.8[a]	-0.1[a]	0.0[a]	0.5[a]	0.54
FOP (Fat off)	15.4[a]	23.2[b]	34.7[c]	47.1[d]	66.8[e]	2.48
FOP (Fat on)	16.2[a]	22.4[b]	32.3[c]	42.2[d]	58.4[e]	2.39
WHC (Whatman) (mg/cm²)	2.0[a]	2.0[a]	4.2[b]	6.3[c]	9.6[d]	0.63
WHC (S&S-Plant) (mg/cm²)	1.4[a]	1.6[a]	3.0[b]	4.4[c]	5.6[d]	0.37
WHC (S&S-Lab.) (mg/cm²)	1.4[a]	1.9[a]	3.8[b]	5.6[c]	6.7[d]	0.37
WHC High Speed Centrifugation (g/100g)	13.9[a]	19.3[a]	24.8[b]	27.6[c]	28.9[c]	0.73
Protein Sol. (mg/g)	64.8[a]	60.3[ab]	55.9[b]	47.2[c]	41.2[d]	2.13
pH Ultimate	6.79[a]	6.20[b]	5.71[c]	5.64[cd]	5.58[d]	0.03
Drip Loss (%)	0.9[a]	1.2[b]	3.5[c]	5.6[d]	6.7[e]	0.36
Cure Uptake (%)	10.3[a]	10.1[a]	11.5[b]	10.2[a]	8.6[c]	0.38
Cure Yield (%)	104.1[a]	101.8[b]	101.3[b]	95.1[c]	87.5[d]	0.56
Pigment (mg/g)	1.32[a]	1.17[b]	1.09[b]	1.07[b]	1.09[b]	0.05

[abcde] Means in the same row with different superscripts are different ($p<0.01$)
[1] Standard error of determination