ON-LINE SYSTEM FOR MEASURING THE INTRINSIC COLOUR OF PORK

JAN RUD ANDERSEN, CLAUS BORGGAARD and PATRICIA BARTON-GADE

Danish Meat Research Institute, Maglegårdsvej 2, DK-4000 Roskilde, Denmark

INTRODUCTION

The intrinsic colour of pork, i.e. the pigment content, is an important quality parameter to most consumers. (Pigment content is equal to the sum of myoglobin and remaining haemoglobin contents.) "Pale" meat is invariably associated with poor eating characteristics, irrespective of the cause of the paleness. Meats with low pigment contents, but with otherwise normal technological and quality-related properties, for example, are often mistakenly identified with meats with poor water holding capacity, i.e. PSE-meats.

Furthermore, in the production of processed meats, large differences in pigment content in the raw material will result in products with an undesirable, non-uniform colour.

Natural differences in pigment content in the lean between muscles and breeds exist, and the extensive use of many breeds in Denmark has resulted in wide pigment variations in Danish fresh pork. This has emphasised and actualised the need for a rapid method of assaying meat pigment content; a method sufficiently rapid to allow slaughter line sorting of carcasses in "colour classes" would alleviate problems of the kind mentioned above by directing the meat to proper markets or productions.

We disclose here our initial work on the development of such a rapid system. The system is based on reflection of polychromatic visible light, and it harnesses recent progress in both integrated optics and mathematical modelling.

MATERIALS AND METHODS

A Zeiss model MCS 210 fibre op spectrophotometer and a Zeiss mo CLX 111 light source were through 2 m of bifurcated optical quartz fib bundles connected to a custom bui stainless steel insertion probe. MCS 210 is a high speed diode arr spectrophotometer permitting reco ding of full spectral scans in t visible range (360-780 nm) in a f ms. The CLX 111 light source is powerful (75W) unmodulated Xen short-arc lamp being sufficient bright to allow for the full advanta ges of the fast spectrophotometer The insertion probe is 140 mm lo with an outer diameter of 6 mm. T probe tip is a replaceable kni permitting the probe to pier through skin and fat into muscul tissue. On the side of the probe 8x0.2 mm² slit is cut in order t transmit and receive light via optical fibres. The fibre-ends ar placed randomly in the slit with a equal number of transmitting a receiving fibres. Communicati between probe, light source a detector is controlled by an IBM AT personal computer. Measurements c be remotely prompted and stored usi buttons on the probe.

Calibration of the system is done b measuring the dark current with th light source shutter closed and th probe protected from light. Next, th reflection from a slurry of a mono disperse polystyrene latex (partic diameter of 822 nm) is stored as standard (Borggaard & Nielsen, 1988

With this equipment, reflecti spectra from muscles of 47 carcasse were obtained on the killing lin just before the chilling tunnel, i.e about 45 mins. after slaughter Spectra were recorded from thre insertions along the longissimu dorsi muscle, and from two insertion into each of the quadriceps an biceps femoris muscles; all were fro left sides. The day after slaughter the insertions were identified, and

the muscular tissue surrounding them cut free and homogenised by mincing. Samples thus obtained were analysed by a modification of the normal procedure for pigment content (Hornsey, 1956). The analytical results from approximately one third of the samples with their corresponding reflection spectra were used as learning set for making a mathematical model translating the several hundred data-points in each spectrum into a single number representing the pigment content. The multivariate calibration routine partial least squares (PLS) regression in form of the software programme UNSCRAMBLER (CAMO, 1987) was used. As a successful outcome of multivariate calibrations is contingent on the quality of the learning set, care was exercised in choosing the set with as much variability and representativeness as possible.

The remaining two thirds of corresponding pairs of reflection spectra and pigment contents were used as a test set to evaluate the model developed.

RESULTS

A typical reflection spectrum originating from a freshly slaughtered animal as obtained with the fibre optic insertion probe described above is shown in Figure 1. It is worth noticing that the signal-to-noise ratio is adequate with ms integration times, indicating a substantial light through-put in the optical fibres. Apparently, longer fibre bundles may be used without major problems.

Visible spectra as the one shown in Figure 1 may be truncated into colour coordinates such as Yxy (Commission Internationale d'Eclairage, CIE, 1931) or L* a* b* (CIE, 1976) values (Frances & Clydesdale, 1975). This is done, e.g., in the Canadian Colormet portable spectrophotometer (Swatland, 1986; METRON, 1987). However, colour coordinates do not give the best measure of intrinsic colour, i.e. pigment content, as they are influenced by the structure and pH of the meat.

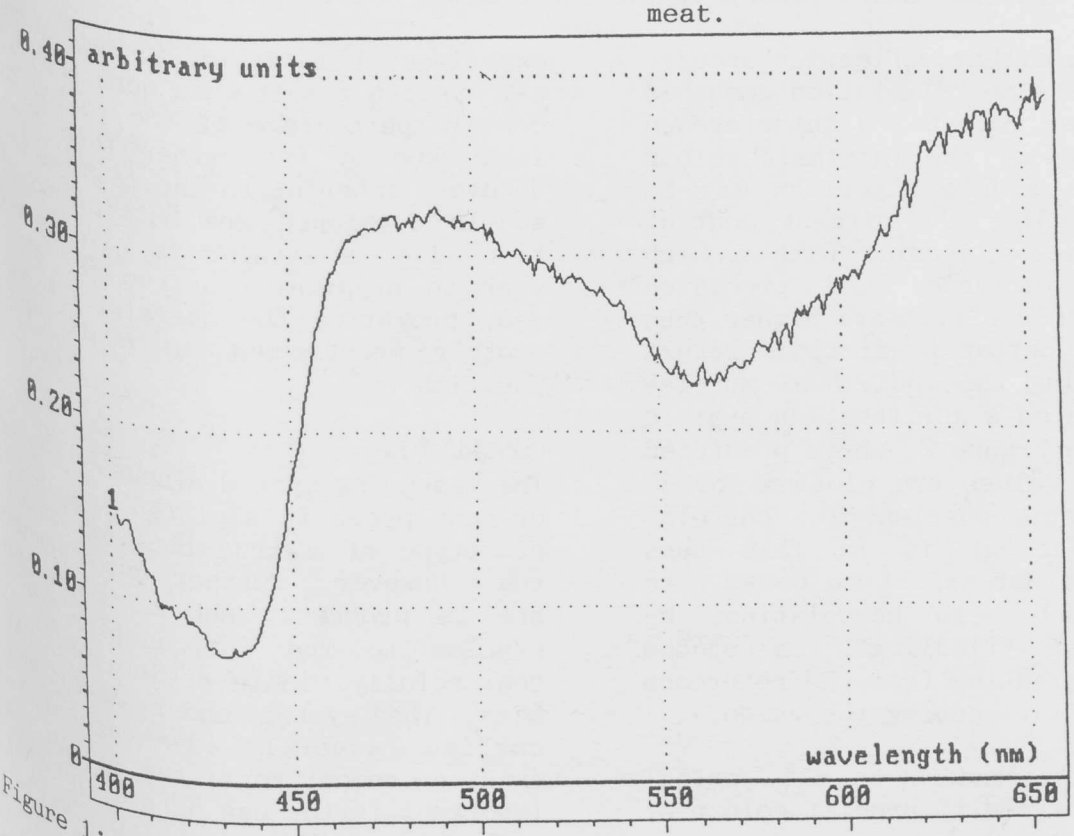

Figure 1: Reflection spectrum from longissimus dorsi muscle obtained with the fibre optic insertion probe on the warm carcass.

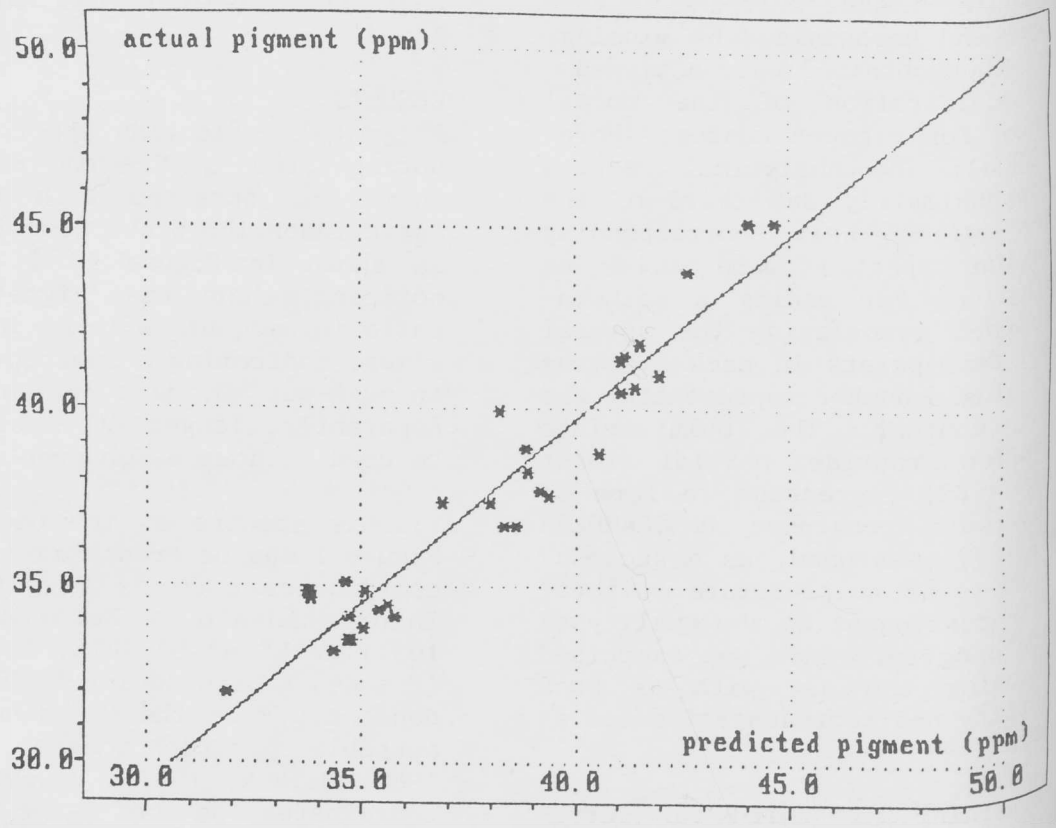

Figure 2: Scatter plot of predicted versus actual pigment concentration in 3 biceps femoris muscles. The correlation coefficient is 0.96.

We have found that reflection spectra and multivariate calibration combined yield a more robust and interference free measure of the intrinsic colour of meat. A single algorithm may be used to predict the pigment content in the muscles studied with a high degree of accuracy and precision (correlation coefficients higher than 0.9). Even better predictions result from treating the individual muscles with dedicated algorithms. An example is given in Figure 2, where predicted and actual values are plotted for 32 biceps femoris muscles. The correlation coefficient is in this case 0.96. We do not expect to be able to improve such high correlations by mathematical "fiddling", as random errors originating from the reference method are influencing the value.

A matter of concern to all optical methods designed to predict colour or pigment contents from point measurements is marbling fat. With our experimental insertion probe, atypical spectra result when more than a certain percentage of the reflection is caused by fat rather than lean. However, inherent to the mathematical models developed are outlier detection, i.e. a warning is given whenever an atypical spectrum is recorded, prompting the operator to make another measurement in a different position.

CONCLUSION

The measuring system discussed in the present paper is admittedly an early prototype of a true on-line apparatus. However, further developments are in progress, and no major obstacles to the introduction of a commercially viable device are foreseen. The system under development carries several advantages over existing competitors; the single most important is the use of polychromatic reflection combined with multivariate calibration procedures.

REFERENCES

Borggaard, C. & Nielsen, T. (1988): Danish patent application No. 6434/88.

CAMO Computer Aided Modelling A/S, Norway (1987).

Francis, F.J. & Clydesdale, F.M. (1975): Food colorimetry, theory and applications. AVI Publishing Co., Westport CT, USA.

Hornsey, H.C. (1956): The colour of cooked cured pork I. Estimation of the nitric oxide-haem pigments. J.Sci.Food Agric., 7, 534-540.

METRON Instruments Inc., Canada (1987).

Swatland, H.J. (1986): Color measurements on pork and veal carcasses by fiber optic spectrophotometry. Can.Inst.Food Sci.Techol., 19, 170-173.