THE USE OF REFLECTANCE MEASUREMENTS AT SELECTED WAVELENGTHS TO PREDICT THE AMOUNT AND PROPORTION OF MYOGLOBIN IN A RANGE OF MEAT SPECIES

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S-V.12

SUMMARY

The reflectance spectra of a range of meat species and muscle types were measured, CIE colour co-ordinates were calculated and the reflectance values at specific wavelengths were obtained. Myoglobin and haemoglobin content of the meat was determined using HPLC.

Significant differences between the CIELAB values were obtained with the leg meat of poultry being significantly more red than that of breast meat. K/S ratios at 525 nm correlated positively with total haem pigment. The use of different equations to calculate pigment proportions did not give comparable results across muscle types.

Introduction

The colour of meat depends on the amount and type of pigment present and the light scattering properties of the meat. Pigments can be extracted and then determined using a variety of methods usually involving conversion to a single chemical form (Wariss, 1979; Karlsson and Lundstrom, 1991).

Using high performance liquid chromatography (HPLC) it is possible to quantify the amount of myoglobin and haemoglobin in meat (Oellingrath *et al.*, 1990). Chemical extraction procedures change the proportions of oxymyoglobin, myoglobin and metmyoglobin present in the meat thus, to measure these *in situ*, reflectance methods must be used. By measuring the reflectance over the visible range, the CIE colour co-ordinates can be calculated and specific wavelengths used to calculate pigment content and proportions. Several formulae based on absorption maxima and isobestic points have been proposed to calculate both the quantity and proportion of the haem pigment. Stewart *et al.* (1965) showed that the ratio of absorption to scattering (K/S) at 525 nm correlated linearly with chemically extracted haem pigment. Krzywicki (1979) proposed that reflex attenuance values (RA) at 730 nm could be used as a measure of non-pigment components of beef. Such an approach appears also to work for pork (Campbell, 1984). For chicken, which shows relatively little blooming when a freshly cut surface is exposed to air (Millar *et al.*, 1994), the Krzywicki approach does not seem to be appropriate. The aim of the present paper is to evaluate how reflectance data can be used to predict the content and proportion of pigments in a wide range of meat types.

Experimental

Reflectance spectra of 10 samples of chicken, turkey and goose leg and breast meat and the Longissimus dorsi from beef and pork were measured using diffuse/0° geometry (Monolight Instruments). CIEXY2 and CIELAB colour co-ordinates were calculated using the weighted ordinate method for the D65 illuminant and 10° observer curve. Reflectance values were obtained at 473, 474, 507, 571, 572, 573, 580, 597, 630, 632 and 730 nm. The amount and proportion of haem pigments was calculated according to the equations of Dean and Ball (1960), Stewart *et al.* (1965), Snyder and Armstrong (1967), Van den Oord and Wesdorp (1971) and Krzywicki (1979) as listed by Mohan Raj (1988).

Statistical Analysis

Analysis of variance was undertaken to identify species differences and differences between breast and leg meat in the 3 poultry species studied. A number of correlation matrices were calculated to relate reflectance values and calculated pigment proportions to CIE colour co-ordinates and pigment content as determined by HPLC.

Results and Discussion

Analysis of variance for the differences in CIE colour co-ordinates showed that there was a significant ($p<0.01$) difference between species/muscle type and overall between poultry breast and leg meat (Table 1). Although goose breast muscle has higher a* values than goose leg muscle, contrary to turkey and chicken, it can be seen that the hue angles of all the leg muscles are lower, that is 'more red', than the corresponding breast muscles. The higher a* values of goose breast may reflect the high haemoglobin content in this muscle (Table 2). The haem pigment results show the relatively high contribution haemoglobin may make to the overall appearance of poultry meat and also the pork in this particular sample set.

Stewart *et al.* (1965) using the isobestic point at 525 nm, common to all 3 pigment forms, showed that the reflex attenuance (RA525) and particularly the K/S ratio (K/S525) correlated positively with the amount of haem pigment present in pork and beef. In the present experiment a similar positive relationship between RA525 and K/S525 with both myoglobin and total haem pigment was obtained over all the muscle types for which pigment content was measured. The relationship between K/S525 and total haem pigment content appeared to be curvilinear although more data points between 4 to 6 mg g^{-1} haem pigment are needed to confirm this observation. Van den Oord and Wesdorp (1971) used the difference between reflex attenuance at 580 and 630 nm (RA580-RA630) to predict oxymyoglobin content, but commented that this calculation was also related to total pigment content. A positive linear relationship between total haem and (RA580-RA630) in the present experiment supports this observation over a wide range of haem contents.

The 3 methods used to calculate oxymyoglobin content (Table 3) do not appear to correlate when applied over a wide range of meat species/muscle types. In particular the ratio RA580/RA525, which should be less influenced by total pigment content, gives a relatively constant value for all species/muscle types compared to the other methods. The Krzywicki (1979) method gave invalid results for turkey breast since the ratio (RA572-RA730)/(RA525-RA730) was larger than the theoretical value calculated from extinction coefficients. This same problem has been noted previously in chicken breast and appears to be due to the low overall reflex attenuance values of poultry breast meat (Moss and Millar, unpublished results). Furthermore, changes in light scattering with wavelength, with the result that RA730 is not a true measure of 'non pigment' absorption at all wavelengths, may partly account for this discrepancy. In more highly pigmented meat types eg beef there does not appear to be a problem since the ratio of absorption to scattering (K/S) is much greater.

In conclusion the current data shows that the K/S ratio at 525 nm may be used to predict total myoglobin and total haem pigment over a wide range of meat species. Other equations developed to assess the amount or proportion of specific pigment forms and originally developed for studies on beef cannot be directly applied to other species/muscle types.

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