Visible/near-infrared spectroscopy to predict water holding capacity in broiler breast meat

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Introduction

The meat industry has increased interest in rapid screening techniques used to predict quality characteristics.[1] Near-infrared (NIR) spectroscopy is considered to be one of the most promising techniques for large-scale meat quality evaluation.[2] Water-holding capacity (WHC) is one of the most important quality characteristics in the poultry industry. One of the major contributors to decreased WHC in the poultry industry has been attributed to pale, soft, and exudative (PSE) broiler breast meat. PSE breast meat is caused by a rapid postmortem pH decline while carcass temperatures are still warm. The resulting protein denaturation leads to a pale color and a decrease in WHC, causing excessive yield losses.[3] PSE incidence in broilers and turkeys has been reported to range from 5 to 50% in commercial plants.[4–9] WHC is essential to maintain high yields, to avoid purge, to ensure juicy muscle and to maintain quality. The objective of this study was to evaluate the influence of L^* and pH on WHC of broiler breast meat and to use vis/NIR spectroscopy to predict WHC.

Materials and methods

Boneless, skinless, broiler breast meat samples were pre-selected and pre-classified into pale and normal categories. L^* values were determined on the dorsal surface of the pectoralis major using a Minolta Chroma Meter CR-310 (Konica Minolta Sensing, Inc., Ramsey, NJ). The pH measurements were acquired through a spear tip Hannah pH meter (Hannah Instruments, Van Nuys, CA). For WHC measurement, a 10 g aliquot of the chopped muscle was mixed with 16 ml of 0.6 M NaCl and then incubated for 30 min at 4°C before centrifuging and obtaining measurement. Samples for vis/NIR analysis were taken from the anterior portion of broiler breast meat, and cores with a 38 mm diameter and 10 mm depth were collected for NIR analysis in the quartz optical cell. The raw core samples from broiler breast meat were scanned using a scanning monochromator (XDS, Foss NIRSystems, Inc., Laurel, MD) and analyzed with Vision Spectral Analysis Software for Windows. Reflectance measurements were recorded over the 400 nm to 2498 nm wavelength range at 0.5 nm intervals and 32 scans. A total of 85 cored breast samples were utilised. All chemometric analyses were conducted using Matlab software with PLS_Toolbox (ver. 4.0, Eigenvector Research, Inc., Manson, WA). Partial least squares regression (PLSR), and principal component regression (PCR) analyses were performed to develop calibration models.

Results and discussion

Mean vis/NIR spectra for breast muscle samples with pHs above (high) and pHs below (low) 5.6 show differences in the spectra at approximate absorbance peaks between 400 and 800 nm and between 1400 nm through 2500 nm (Figure 1).

Mean spectra for the samples with high (>15%) and low (<13%) WHC were similar to the pH spectra in their absorption pattern. From the second derivative spectra, it was observed that the absorbance of high pH samples was higher than the low pH samples at 440 nm and 560 nm but lower at 492 nm, 1400~1500 nm and around 1900 nm. This was consistent with the second derivative spectra for WHC. The 440 nm, 560 nm and 492 nm bands have been associated with deoxymyoglobin, oxymyoglobin, and metmyoglobin, respectively.[10] Bands around 1450 nm and 1900 nm are related to water.[11] The results indicate that pH and WHC of the breast samples are related to myoglobin and water absorption. For mean spectra of L^* samples, the absorption pattern was different from the other two parameters. The samples with high L^* values (> 68) had lower intensity than the samples with low L values (<66) at 440 nm and 560 nm, but higher at 492 nm, around 1450 nm and around 1910 nm.

The scatter plots [Figure 2(a)] of measured versus NIR predicted WHC values of the samples showed the coefficient of determination for cross validation (R^2) of 0.719 and root mean square error of cross-validation (*RMSECV*) of 0.028 using two latent variables.

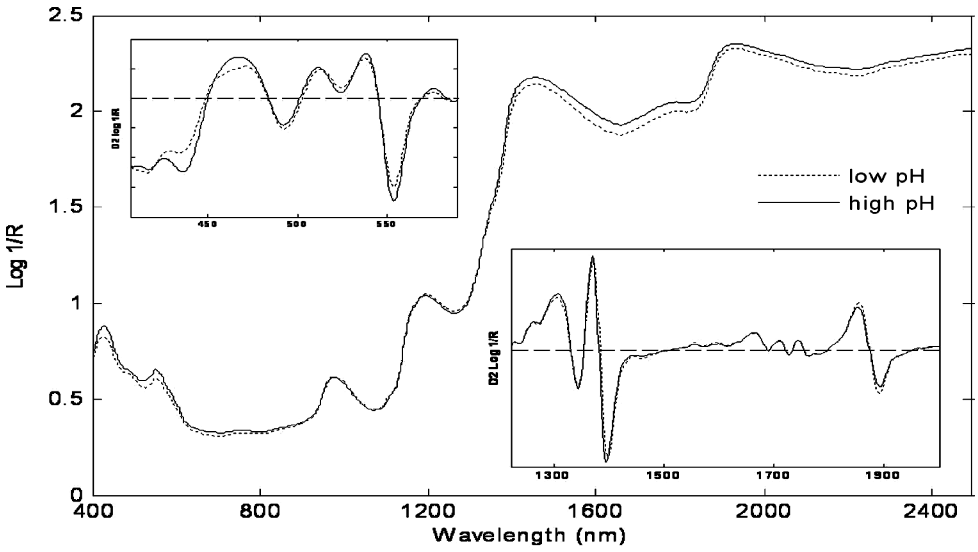

Figure 1. Mean spectra of low pH(<5.6) and high pH (> 5.6) broiler breast samples.

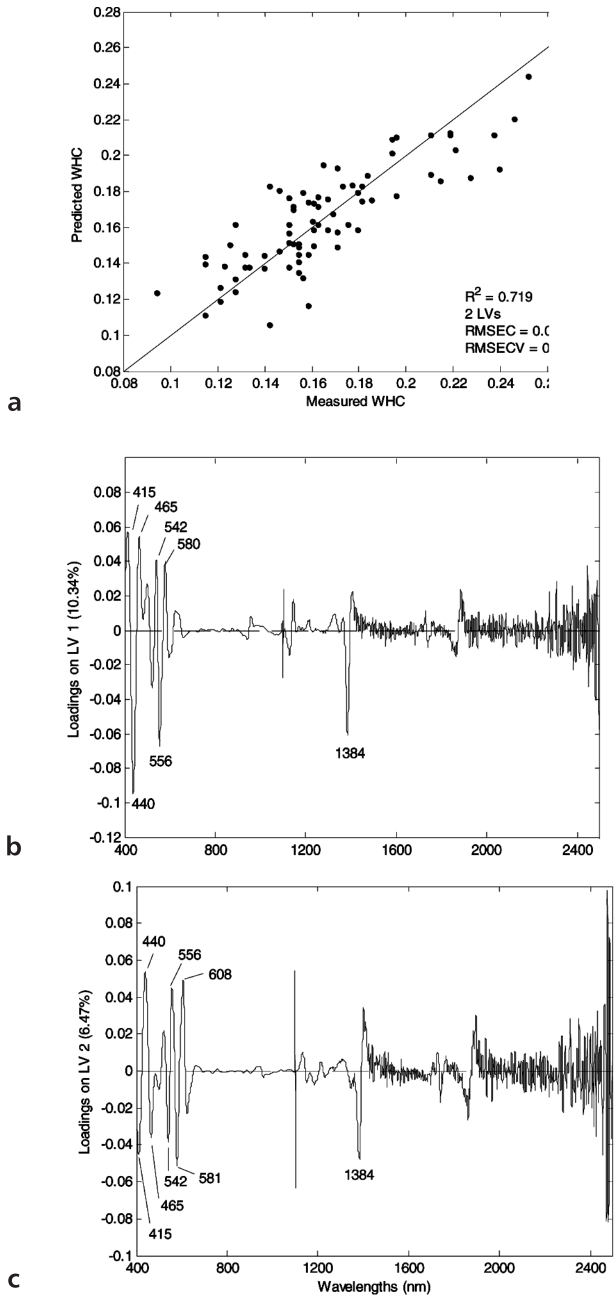

Figure 2. Water holding capacity prediction in broiler breast meat by near-infrared spectroscopy using a partial least squares (PLS) model (a). The two bottom figures are PLS loading plots for WHC of samples using one (b) or two (c) latent variables. Identified peaks at the given wavelengths (415 nm, 440 nm, 465 nm, 542 nm, 556 nm, 558 nm, 580 nm, 581 nm, 608 nm and 609 nm) have the greatest influence on the prediction model.

The loading plots [Figures 2(b) and 2(c)] showed that the wavelengths of between 400 nm and 600 nm that were previously associated with heme pigments[12,13] and the wavelength at around 1384 had the greatest influence in developing the calibration model. The PLS models and loading plots for the pH and L^* values of broiler breast samples resulted in lower prediction errors than the PLS model for WHC.

Conclusions

The results from the PLS model showed that vis/NIR spectroscopy has the potential to predict water holding capacity in broiler breast meat which has conditions resembling PSE meat. The mean spectra for the low and high values of pH, WHC, and L^* of the samples showed differences in wavelengths associated mainly with the heme pigments, myoglobin and hemoglobin, water and protein.

References

1. G. H. Geesink, F. H. Schreutelkamp, R. Frankhuizen, H. W. Vedder, N. M. Faber, R. W. Kranen and M. A. Gerritzen. *Meat Sci.* **65,** 661 (2003).
2. G. Monin. *Meat Sci.* **49,** S231 (1998).
3. C. Z. Alvarado and A.R. Sams. *Poultry Sci.* **82,** 1332 (2003).
4. S. Barbut, Can. J. Anim. Sci. **76,** 455 (1996).
5. S. Barbut. *British Poultry Sci.* **38,** 74 (1997).
6. R.D. McCurdy, S. Barbut and M. Quinton. *Food Res. Int.* **29,** 363 (1996).
7. C.M. Owens, E.M. Hirschler, S.R. McKee, R. Martinez-Dawson and A.R. Sams. *Poultry Sci.* **79,** 553 (2000).
8. R.L. Woelfel, C.M. Owens, E.M. Hirschler, R. Martinez-Dawson and A.R. Sams. *Poultry Sci.* **81,** 579 (2002).
9. R.L. Woelfel and A.R. Sams. *Poultry Sci.* **80,** 1519 (2001).
10. Y. Liu and Y.R. Chen, *Appl. Spectrosc.* **54,** 1458 (2000).
11. B. Osborne, T. Fearn and P. H. Hindle. *Practical NIR Spectroscopy with Applications in Food and Beverage Analysis*. Longman Scientific & Technical, Harlow, Essex, UK (1993).
12. M. Mitsumoto, S. Maeda, T. Mitsuhashi and S. Ozawa, *J. Food Sci.* **56,** 1493 (1991).
13. D. Cozzolino and. I. Murray. *J. Near Infrared Spectrosc.* **10,** 37 (2002).