PREDICTION OF BEEF CIELAB COLOUR FROM RGB DIGITAL IMAGES

A. Brugiapaglia[1*], A. Albera[2], S. Savoia[2], G. Destefanis[1] and L. Di Stasio[1]

[1] Department of Agricultural, Forest and Food Sciences (DISAFA) of the University of Torino, Italy
[2] Associazione Nazionale Allevatori dei Bovini di Razza Piemontese, Carrù (CN), Italy

*Corresponding author email: alberto.brugiapaglia@unito.it

Abstract - The aim of this study was to evaluate the performances of a quadratic model to predict CIELAB parameters from digital images. The colour of 80 *longissimus thoracis* samples was measured by a spectrophotometer in the CIELAB space model and photographed using a digital camera which produced RGB images. All the images were captured under controlled conditions. The RGB colours were measured using Photoshop software. The conversion of RGB values to L*a*b* values was carried out using a quadratic model. The percent mean absolute error ($\bar{e}\,\%,$), standard deviation of the percent mean absolute error (σ), average root mean square error ($\overline{RMSE}$) and colour difference (ΔE*) were used for measurement of differences between the values obtained with the spectrocolorimeter and Photoshop. The model showed an error of 1.36% and a standard deviation of 1.12. The ($\overline{RMSE}$) was 1.28 while the ΔE* was equal to 2.94. The proposed method achieves a promising performance, however the acquisition of the images needs some adjustments to improve the accuracy of the model.

Key Words – colour space transformation, computer vision, image analysis, quadratic model.

I. INTRODUCTION

Meat color may be assessed objectively using tristimulus colorimeter and spectrophotometer, which measure colour in the device independent CIELAB colour space. These instruments only provide average values of a small area of the sample, and therefore, many locations must be measured to obtain a representative colour profile [1]. Moreover these locations are chosen depending on the sample, for example to avoid visible fat and connective tissue, making the measurements subjective and hard to reproduce. Furthermore these location do not always reflect the colour variation of the entire sample [2]. In recent years, digital camera imaging has been used to objectively measure meat colour since it provides some advantages over a conventional colorimeter, namely, the possibility of analysing the entire surface of meat, its characteristics and defects [3]. The digital image analysis uses the RGB colour model in which each sensor of the camera capture the intensity of the light in the red (R), green (G) and blue (B) spectrum, respectively. As the digital camera gives the colour in RGB values that cannot be transformed to L*a*b* value directly by using standard formula, a transformation that defines the mapping between the device dependent RGB digital values and a device independent colour space is necessary to obtain high fidelity colour reproduction [4]. Therefore, this study was carried out in order to test if a quadratic model provides a good estimation of CIELAB parametres from RGB measurements of meat.

II. MATERIALS AND METHODS

Eighty *longissimus thoracis* steaks from Piemontese bulls were employed in this study. After 1 hour of blooming, the colour of each sample was measured by a Minolta spectrophotometer CM-600d (measuring aperture of 8 mm) and the results were expressed in terms of lightness L*, redness a*, yellowness b*. Immediately after, the samples were illuminated with two daylight 5400 K fluorescent lamps placed about 60 cm above the meat at an angle of 45°. Before taking the photo, the samples were lightly dried with a napkin to remove surface liquids. A Nikon D3100 digital camera was placed vertically at a distance of 50 cm from the sample and the focus was set at 35 mm. Pictures were taken using A mode, with the aperture value set to f/4.5 at ISO 100. All the images were saved into JPEG file and the RGB colours were measured using Abode Photoshop software (Adobe System Inc., San Jose, CA, USA). The meat samples were divided into two sets. A set of 54 L*a*b* and RGB measurements were used for calibration, and the remaining 26 were set aside for validation. In the calibration step, the conversion of RGB color values to L*a*b* values was carried out using a quadratic model which considers the influence of the square of RGB variables on the estimation of the L*a*b* values. For L*, the quadratic model can be expressed as follow:

$$\begin{vmatrix} L_1^* \\ \dots \\ L_n^* \end{vmatrix} = \begin{vmatrix} R_1 & G_1 & B_1 & R_1G_1 & R_1B_1 & G_1B_1 & R_1^2 & G_1^2 & B_1^2 & 1 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ R_n & G_n & B_n & R_nG_n & R_nB_n & G_nB_n & R_n^2 & G_n^2 & B_n^2 & 1 \end{vmatrix} \begin{vmatrix} a_1 \\ \dots \\ a_{10} \end{vmatrix}$$

Here "n" is the total number of meat samples and the vector A includes all coefficients to be determined to transform RGB to L*. Using the same procedure, the coefficients of polynomial functions from RGB to a* and b* were calculated. Once the system was calibrated, it was possible to infer the L*a*b* values on the basis of RGB measurements from camera without having to use the spectrophotometer. Mean percent absolute error

($\bar{e}$ (%)), standard deviation of the mean percent absolute error (σ), average root mean square error ($\overline{RMSE}$) and CIE colour difference (ΔE*) were used for measurement of differences between the values obtained with the spectrophotometer and Adobe Photoshop. All the calculations were performed using Microsoft Excel and XLSTAT (Addinsoft, Paris, France) a statistical add-in for Microsoft Excel.

III. RESULTS AND DISCUSSION

Calibration and validation processes were carried out separately by calculating percent mean absolute error, standard deviation of the percent mean absolute error, average root mean square error and CIE colour difference (Table 1).

Table 1. Measured and predicted L*a*b* values (mean ± standard deviation), mean percent absolute error ($\bar{e}$ (%), standard deviation of the mean percent absolute error (σ), average root mean square error ($\overline{RMSE}$) and CIE colour difference (ΔE*).

Measured values			Predicted values						
L*	a*	b*	L*	a*	b*	$\bar{e}$ (%)	σ	$\overline{RMSE}$	ΔE*
41.44±3.23	19.06±2.41	16.43±1.79	41.64±2.76	19.58±1.23	16.90±1.07	1.36	1.12	1.28	2.94

In comparison with data reported by Tarlak *et al.* [5], who used a quadratic model to trasform RGB colour units to L*a*b* values of meat, we found a higher $\bar{e}$ (%) value (1.36 *vs* 1.15). On the contrary, the prediction performance of our model was better than that of Tarlak *et al.* [5] showing a lower $\overline{RMSE}$ value (1.28 *vs* 1.75). Valous *et al.* [6] used the computer vision system to evaluate the quality of pre-sliced hams and reported, for various polynomial models including quadratic and cubic terms, ΔE* values greater than 4.0. Barbin *et al.* [7] who followed two steps conversion model (RGB→XYZ→L*a*b*) reported that ΔE* value for poultry meat was less than 5.2, while Tarlak *et al.* [5] who used a quadratic model found in meat a ΔE* value of 3.25. In our work, the ΔE* value was lower than that reported by the other Authors and the main contribution to the whole colour difference came from a* and b*.

IV. CONCLUSION

The meat surface is a critical factor affecting the measurements precision. Because the camera measured the entire sample surface, it is more representative of sensory descriptors than the colorimeter, which is based on point-to-point measurements. In fact, the presence of visible fat and connective tissue, can greatly influence the mean colour of meat obtained with digital colour devices. The methodology used for RGB to L*a*b* transformation with a quadratic model achieves a promising performance, however the acquisition of the images need some adjustments to validate and improve the accuracy of the model.

ACKNOWLEDGEMENTS

The work was supported in part by MIUR ex60% - BRUA_RILO_16_01 and Fondazione Cassa di Risparmio di Cuneo, research project “QualiPiem – Metodi innovativi per la selezione della qualità nella razza Piemontese”.

REFERENCES

1. Mendoza, F., Dejmek, P. & Aguilera, J.M. (2006). Calibrated color measurements of agricultural foods using image analysis. Postharvest Biology and Technology 41: 285-295.
2. Trinderup, C.H., Dahl, A.L., Jensen, K., Carstensen, J.M. & Conradsen K. (2015). Comparison of a multispectral vision system and a colorimeter for the assessment of meat color. Meat Science 102: 1-7.
3. Girolami, A., Napolitano, F., Faraone D. & Braghieri A. (2013). Measurement of meat color using a computer vision system. Meat Science 93: 111-118.
4. León, K., Mery, D., Pedreschi F. & León, J. (2006). Color measurements in L*a*b* units from RGB digital images. Food Research International 39: 1084-1091.
5. Tarlak, F., Ozdermir, M. & Melikoglu, M. (2016). Computer vision system approach in colour measurements of food: Part II. Validation of methodology with real foods. Food Science and Technology 36: 499-504.
6. Valous, N.A., Mendoza, F., Sun, D.W. & Allen P. (2009). Colour calibration of a laboratory computer vision system for quality evaluation of pre-sliced hams. Meat Science 81: 132-141.
7. Barbin, D.F., Mastelini, S.M., Barbon, S. Jr., Campos, G.F.C., Barbon, A.P.A.C. & Shimokomaki M. (2016). Digital image analyses as an alternative tool for chicken quality assessment. Biosystems Engineering 144: 85-93.