Analele Universităţii de Vest din Timişoara
Vol. LV, 2011
Seria Fizică

THE USE OF CIE L*a*b* COLOUR SPACE FOR AUTOMATIC PORK MEAT CONTENT ANALYSIS

Alin C. Teuşdea, Adrian Timar, Olimpia S. Mintaş, Lucian Bara

University of Oradea, Faculty of Environmental Protection, Gen. Magheru 26, Oradea 410058, BH, Romania

Article Info
Received: 29 December 2010
Accepted: 16 January 2011

Keywords:
colour,
image analysis,
CIE L*a*b*.

Abstract
This paperwork aims to use a non-invasive research method in assessing fresh pork meat content. The method is based on the colour image analysis (NIR-CIA) algorithm of scanned pork meat at the end of the technological process. The content of fresh pork meat has two basic classes: fat and muscle. CIE L*a*b* colour space for colour coding and class discrimination is used by the classification process. The meat categories studied are the fresh pork steak, gammon, reed and rib.

1. Introduction

The principal aim of this paper is to find a non-invasive and fast research method to assess the quality of pork meat from quantitative and hygienic point of view [1]. The method must be proper for industrial application and for aggressive environments. Thus, the main goal is to identify (i.e. to classify) the fresh pork meat content for two basic classes: fat and muscle [2].

For assessing the content of the fresh pork meat several colour image analysis researches were done [3-5]. As a consequence in many countries there are standards regarding the industrial use of this method – but not yet in the author's home country. The classification process is based on converting the digital scanned fresh pork meat images in CIE L*a*b* colour space [6-8] which has the advantage of being a linear space. In this paper the classification process has a training stage to asses the CIE L*a*b* chromatic limits for each class by using the reference class images.

2. Method and samples

Digital images are usually coded in RGB (Red Green Blue coordinates) colour space. Each coordinate has the integer number range between 0 and 255. This colour space is used to capture and transfer the digital images.

In many industries the CIE L*a*b* colour space is used because it is approximately a uniform space. The L* coordinate denotes the lightness and has a range between 0 and 100. The L* zero value represents black and the 100 value for represents white. Coordinates a* and b* have no specific numerical limits, and they denote the chromaticity. Positive a* values denote red and negative a* value denotes green. Positive b* value denotes yellow and negative b* values denote blue. The chromatic plane is organized so that a* and b* axes have complementary colours at their ends.

The main issue, when one wants to process digital captured images, is to transform their RGB coding to CIE L*a*b* coding [6, 7] (figure 1). This transformation is done in two steps. First the RGB space is transformed in XYZ uniform space and then in CIE L*a*b* space. The RGB to CIE L*a*b* transformation numerical algorithm is as follow [6, 7]

$$r = R/255\,;\; g = G/255\,;\; b = B/255 \tag{1}$$

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 0{,}4124 & 0{,}3576 & 0{,}1805 \\ 0{,}2126 & 0{,}7152 & 0{,}0722 \\ 0{,}0193 & 0{,}1192 & 0{,}9505 \end{pmatrix} \cdot \begin{pmatrix} fg(r,a,\gamma) \\ fg(g,a,\gamma) \\ fg(b,a,\gamma) \end{pmatrix} \tag{2}$$

where

$$fg(c,a,\gamma) = \begin{cases} \left(\dfrac{C+a}{1+a}\right)^{\gamma}, \text{if } \; C > 0.0405 \\ \mathrm{C}/12.92\,, \text{otherwise} \end{cases}, \tag{3}$$

$$f(t) = \begin{cases} t^{(1/3)}, t > (6/29)^3 \\ 1/3 \cdot (29/6)^2 t + 4/29, \;\; \text{otherwise} \end{cases}, \tag{4}$$

$$L = 116\, f(Y/Y_0),\;\; a^* = 500\left[f(X/X_0) - f(Y/Y_0)\right],\;\; b^* = 200\left[f(Y/Y_0) - f(Z/Y_0)\right]. \tag{5}$$

According the CIE L*a*b* 1992 model the constants are $a = 0.055$ and $\gamma = 2.2$ [6, 7]. The tristimulus point coordinates, $(X_0;Y_0;Z_0)$, depends on the illuminating source used to capture the image.

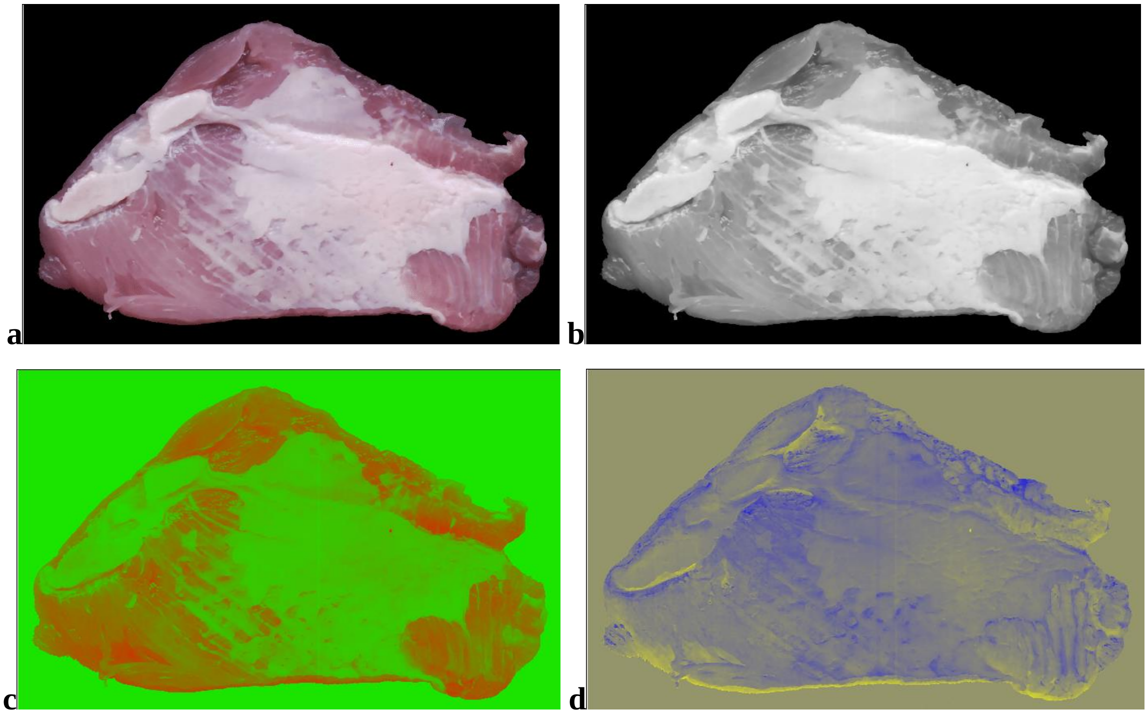

Figure 1. Example of RGB to CIE L*a*b* colour space transformatiof of pork meat: a – original RGB scanned image; b – L* component image; c – a* component image; d – b* component image.

The images coded in CIE L*a*b* colour space described above can be compared more accurately [6-8].

3. Results and Discussions

In this paper, eight samples of fresh pork meat chops without bones: steak, gammon, reed and rib were scanned. The optical resolution of the scanned images is 300×300 dpi (i.e. 0846 mm×0.0846 mm for a pixel) and the background used is black. The chops were scanned on both sides, thus there were 64 scanned images. The pre-processing step consists in an edge preserving smoothing with the amount of 3 pixel parameter. This step reduces the effect of pixelization during the scanning process of the pork meat chops with a high intensity of specular optical reflection.

The aim of the image colour analysis of fresh pork meat is to asses an algorithm which discriminates the targeted classes: red meat (i.e. muscle) and fat [1-5, 8].

The numerical discrimination algorithm uses the CIE L*a*b* colour space coding. So, the first step is to calculate the CIE L*a*b* coordinates of the scanned images (equations 1-4).

The second step is to calibrate the discrimination process for the targeted classes. In this step the operator selects regions of targeted classes and determines the CIE L*a*b* properties (i.e. numerical limits) of them [1-5, 8].

In order to determine the numerical values for the tri-chromatic limits of the two targeted classes, the 2D histogram of the chromatic plane (coordinates a* and b*) was calculated. Figure 2 presents the histogram for both classes: red meat (dark mesh color with light wireframes) and fat (light mesh color with dark wireframes).

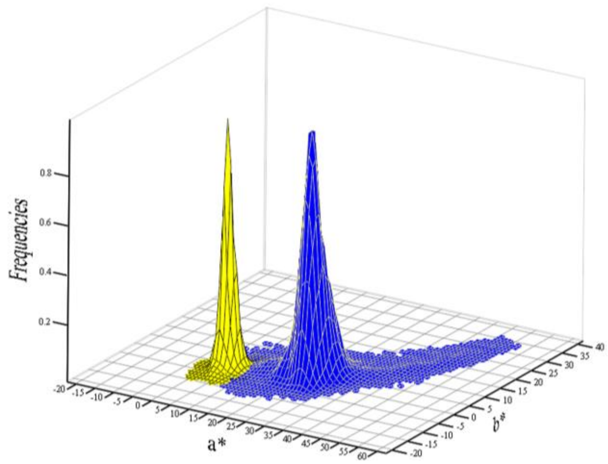

Figure 2. The 2D histogram representation of CIE L*a*b* chromatic plane with unit normalized frequencies for the two targeted classes.

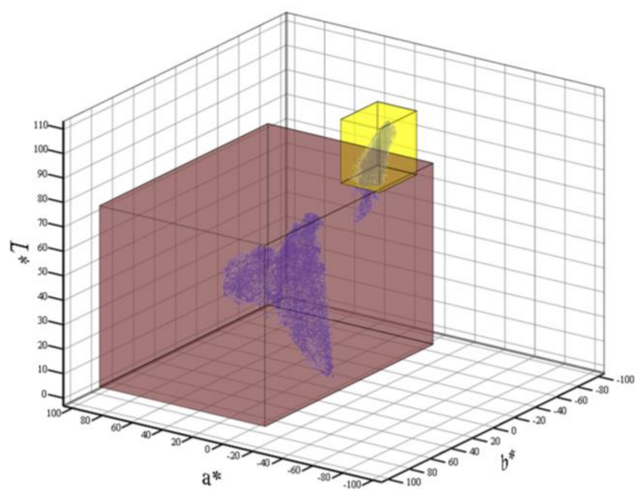

Figure 3. The CIE L*a*b* targeted classes limits represented as rectangular prisms, embedding the references points clouds of red meat (in dark box) and fat (in light box).

From this histogram the numerical values of the limits which made the discrimination (classification) of the targeted classes were depicted. These limits can be represented by rectangular prisms in 3D CIE L*a*b* space (figure 3).

The third step is to classify of the original scanned pork meat image into targeted classes (figure 4). Counting the number of the pork meat pixels that belongs to the targeted classes and generating the meat content report is the last step.

Conclusions

In the present paperwork, the percentage content of fresh pork meat (i.e. red meat and fat) was assessed. This task was done by using the non-invasive research with colour image analysis technique (NIR-CIA). The percentage content of the fresh pork meat was generated as a result.

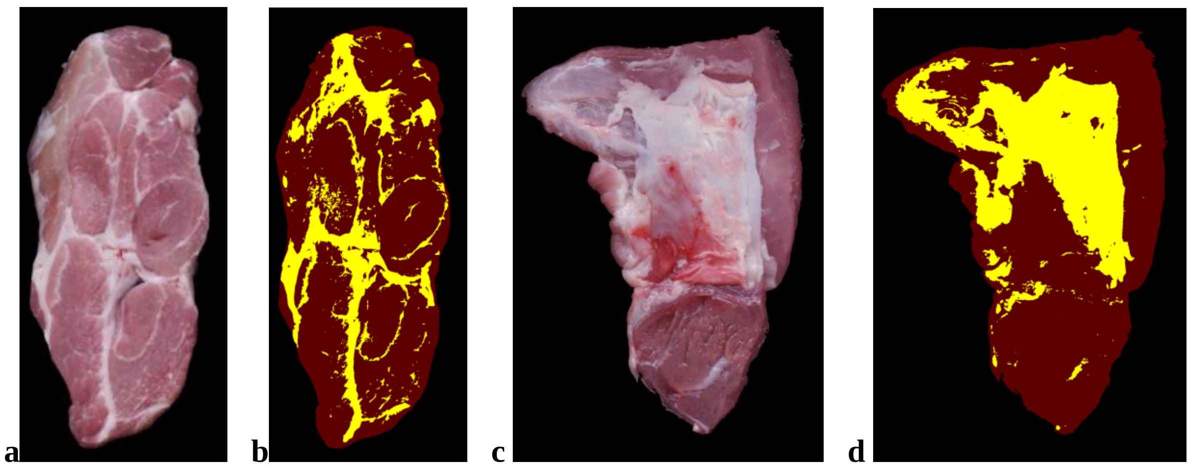

Figure 4. Pork steak sample: a, c – original scanned RGB image; b, d – image after NIR-CIA classification; fat class with light colour and read meat class with dark colour.

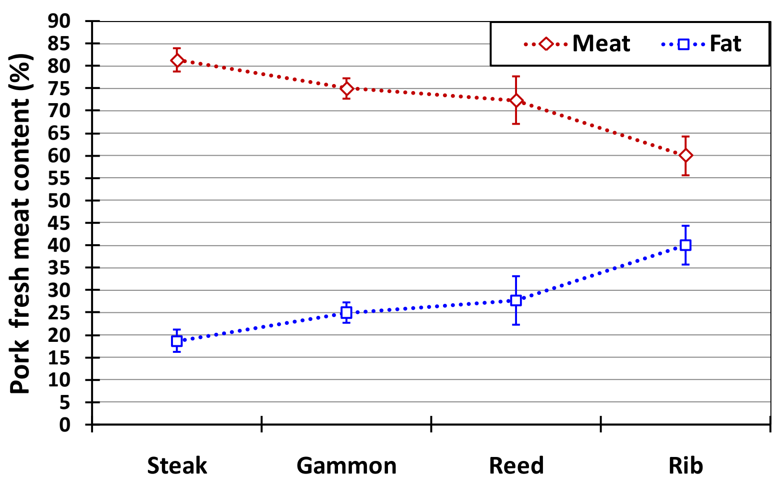

Figure 5. NIR-CIA classification results on fresh pork meat – average and standard deviation values of red meat and fat content.

Figure 5 presents the fresh pork meat content report – as being the averaged values. The fat/red meat content of the steak, gammon, reed and rib pork chops categories, are in the limits prescribed by worldwide standards [1-5, 8]. A minimum of 2.5% gap between the fat/red meat categories can be noticed. This fact reveals a possible categories discrimination criteria that the NIR-CIA method can achieve. Furthermore it can be noticed a very large standard deviation values that the reed and rib pork meat categories

present. The main cause that generates this issue is that the designated fresh pork meat samples were chopped to close to a different category region. This means that, from the eight samples of each of these categories, some could be corrupted.

The NIR-CIA method, previously presented, is proved to be very accurate and fast for revealing the fresh pork meat content that can generate a quality meat product report. Future work can involve a larger category sample database in order to generate analysis results with greater statistical significance.

References

1. O. Fumiere, P. Veys, A. Boix, C. von Holst, V. Baeten, G. Berben, Biotechnol. Agron. Soc. Environ., **13** (S) (2004) 59.
2. F. J. Tan, M. T. Morgan, L. I. Ludas, J. C. Forrest, D. E. Gerrard, J. Anim. Sci., **78**, (2000) 3078.
3. F. G. Del Moral, F. O'Valle, M. Masseroli, R.G. Del Moral, Journal of Food Engineering, **81** (2007) 33.
4. D. L. Hopkins, E. Safari, J. M. Thompson, C. R. Smith, Meat Science, 67 (2004) 269.
5. P. Pipek, J. Jelenikova, L. Sarnovsky, Czech J. Anim. Sci., **49** (3) (2004) 115.
6. C. Vienne: Central Bureau of the Comission Internationale de l'Eclairage, 2nd Edn. Publication CIE No. 115, 2.CIE (1986).
7. K. Leon, D. Mery, F. Pedreschi, J. Leon, Food Research International, **39** (10) (2006) 1084.
8. D. Ave, Guidelines for Meat Color Evaluation, Published by the American Meat Science Association 1111 N., Savoy, IL 61874 USA, www.meatscience.org, (1991).