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THE USE OF CIE L*a*b* COLOUR SPACE FOR SMOKED FISH MEAT CONTENT ASSESMENT

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Abstract
The major aim of this paper is to find a non-invasive and fast research method to assess the quality of fish meat from quantitative and hygienic point of view [1]. This method must be proper for industrial application and for aggressive environments. Thus, the main goal is to identify (i.e. to classify) the fish meat content in percentages for the five classes: red meat, fat, muscle, bone, skin.
For assessing the content of the fish meat many colour image analysis researches were done worldwide [2-4]. There were made classifications for only three classes (muscle, bone, fat).
In this paper the classification process is based on converting the digital scanned smoked fish meat images in CIE L*a*b* colour space [5, 6] which has the advantage of being a linear chromatic space. Furthermore it has a training stage to asses the chromatic discrimination boundaries for each class by using the reference class images.
For an accurate analysis there is done a comparison ("calibration") between the smoked fish meat content results of the NIR-CIA method with the classical gravimetric invasive method one. This is accomplished with Fourier correlation analysis [7] of the meat content "profiles".

1. Introduction

This paperwork aims to develop an alternative to the classical methods used in assessing the meat content.

The method is based on the non-invasive colour image analysis (NIR-CIA) algorithm of the scanned fish meat at the beginning of the technological process [5, 6]. The content of smoked fish meat has five classes: red meat, fat, muscle, bone, skin. For colour coding and class discrimination the classification process uses CIE L*a*b* colour space.

Calibration of the method is accomplished by comparing the content results with the classical laboratory analysis results. The fish products studied are the smoked carp fillet and chop.

2. Method and samples

2. 1. CIE L*A*B* colour space

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 the range between 0 and 100. The zero value for L* represents black and the 100 value represents white. Coordinates a* and b* have no specific numerical limits, and they denote the chromaticity. Positive a* values denote red and negative a* values denote green. Positive b* values denote yellow and negative b* values denote blue. The chromatic plane is organized so that the 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. This transformation is done in two steps. First the RGB space is transformed in XYZ uniform space and next in CIE L*a*b* space. The RGB to CIE L*a*b* transformation numerical algorithm is as follow [5, 6]

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} 0{,}4124 & 0{,}3576 & 0{,}1805 \\ 0{,}2126 & 0{,}7152 & 0{,}0722 \\ 0{,}0193 & 0{,}1192 & 0{,}9505 \end{pmatrix} \cdot \begin{pmatrix} fg(R/255, a, \gamma) \\ fg(G/255, a, \gamma) \\ fg(B/255, a, \gamma) \end{pmatrix} \tag{1}$$

where

$$fg(c,a,\gamma) = \begin{cases} \left(\dfrac{C+a}{1+a}\right)^{\gamma}, \text{if} \quad C > 0.0405 \\ \text{C}/12.92\text{, otherwise} \end{cases}, \quad f(t) = \begin{cases} t^{(1/3)}, t > (6/29)^3 \\ 1/3 \cdot (29/6)^2 t + 4/29, \quad \text{otherwise} \end{cases} \tag{2}$$

$$L = 116 f(Y/Y_0), \quad a^* = 500[f(X/X_0) - f(Y/Y_0)], \quad b^* = 200[f(Y/Y_0) - f(Z/Y_0)]. \tag{3}$$

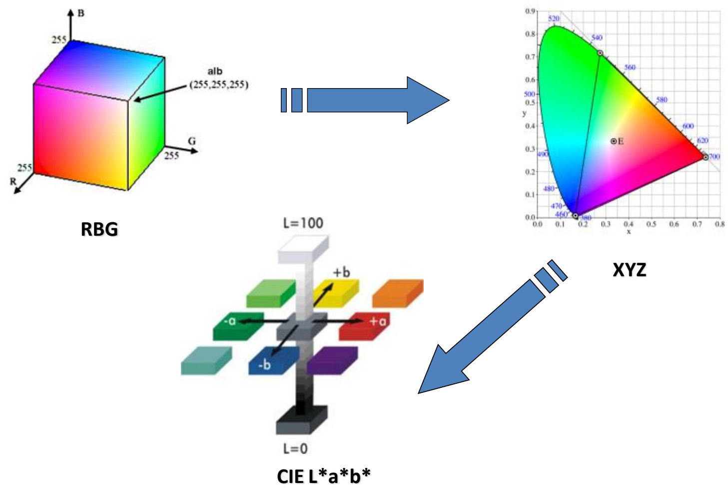

Figure 1. RGB colour space to CIEL*a*b* colour space transformation.

According to CIE L*a*b* 1992 model the constants are $a = 0.055$ and $\gamma = 2.2$ [5, 6]. The tristimulus point coordinates, $(X_0; Y_0; Z_0)$, depend on the illuminating source used to capture the image.

The images coded in CIE L*a*b* colour space, described above, can be compared more accurately [5, 6].

2. 2. Fourier correlation

The correlation process may be a statistical analysis or a Fourier spectral one. The normalized Fourier correlation coefficient, $NFCC$, can be built from the Fourier analysis, described [7] by

$$NFCC(f(x), g(x)) = \max_x \left[\frac{\mathcal{F}^{-1}\left[\overline{F(-u)} \cdot G(u)\right](x)}{\max_x \left[\mathcal{F}^{-1}\left[|F(u)|^2\right](x)\right]^{0.5} \cdot \max_x \left[\mathcal{F}^{-1}\left[|G(u)|^2\right](x)\right]^{0.5}} \right] \quad (5)$$

where $f(x), g(x)$ are two functions, $F(u), G(v)$ are their Fourier transforms.

The statistical significance of the correlation coefficient values is: 0.10 – 0.29 for weak; 0.30 – 0.49 for average, 0.50 – 1.00 for strong [7].

3. Results and Discussions

Two carp chops and two carp fillets were scanned with a Genius Vivid Colour flatbed scanner (with F11 standard illumination lamp). The optical resolution of the scanned images is 300×300 dpi (i.e. 0.0846 mm×0.0846 mm for a pixel) and the background is black. The carp chops were scanned on both sides, thus there were 6 scanned images. The carp chops and fillets were scanned in smoked conditions.

The aim of the image colour analysis, of smoked carp meat, is to asses an algorithm which discriminates the targeted classes: red meat, fat, muscle and if it is possible the bone and skin [2-4].

CIE L*a*b* colour space coding is used by the numerical discrimination algorithm. So, the first step is to calculate the CIE L*a*b* coordinates of the scanned images.

The second step is the discrimination process trainning for the targeted classes. In this step the operator selects regions of targeted classes and determines their CIE L*a*b* properties (i.e. numerical limits).

The CIE L*a*b* limits of the targeted classes can be represented as rectangular prisms (or boxes) that embed the CIE L*a*b* points cloud of the carp chops and fillets (figure 2).

Third step consists in classification of the original scanned carp meat image into targeted classes. Counting the number of the carp chop pixels that belongs to the targeted classes and generating the meat content report is the last step.

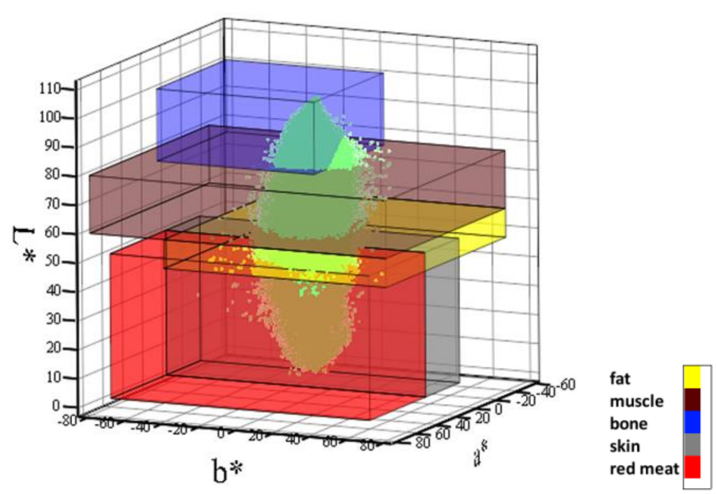

Figure 2. The CIE L*a*b* targeted classes limits (as rectangular prisms or boxes) and the points cloud of a carp chop with targeted classes colour legend.

Classical analysis (gravimetric invasive method) was performed on 6 samples of smoked carp meat.

The skin class is present in carp chops images in a relevant way. In the carp fillets images the skin class is not accurately discriminate, because the skin is located on the other side of the fillets and it was not scanned.

Figure 3. Example of RGB to CIE L*a*b colour space transformation of: a - Smoked carp chop scanned image; b - Smoked carp chop image with targeted classes.

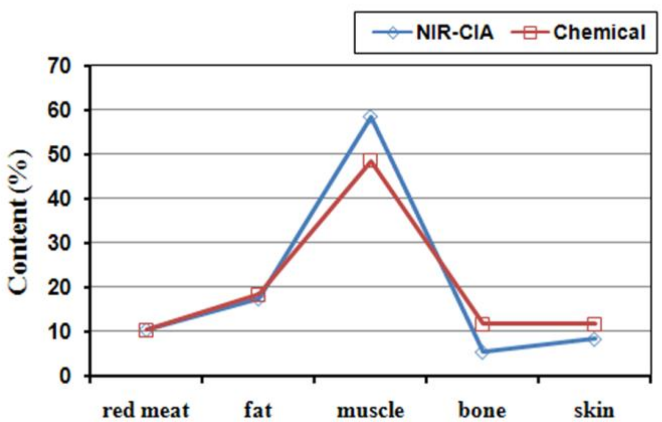

Figure 4. All targeted classes content (%) profiles for a smoked carp chop.

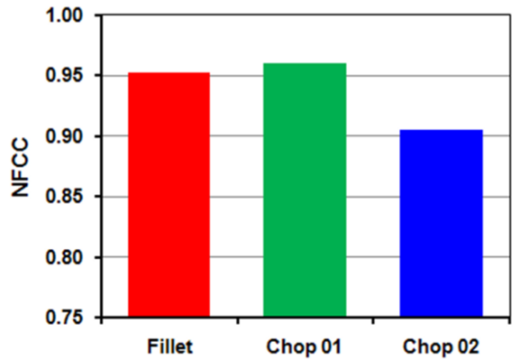

Figure 5. Correlation results for the smoked carp meat.

In order to compare the accuracy of the NIR-CIA (Non-Invasive Research – Colour Image Analysis) method, the classical invasive content analysis was done, too.

4. Conclusions

In the present paperwork was assessed the percentage content of smoked fish meat (i.e. carp chops and fillets). This task was done using the non-invasive research with colour image analysis technique (NIR-CIA) in CIE L*a*b* colour space [1-4]. The percentage content of the smoked fish meat was generated as a result, for five classes.

The Fourier correlations of the fish meat content "profiles" generated by NIR-CIA and classical gravimetric analysis are presented in figure 3. In this way assessing the fish meat content has higher statistical accuracy.

As previously mentioned, the correlations are strong and the *NFCC* values are close.

The strong correlation results for the smoked carp meat denote that the NIR-CIA method is an accurate method in assessing the smoked fish meat content and the quality of fish products.

This method prove to be non-invasive and very fast for revealing quality defects, including red meat and quality parameters such as protein content (muscle), fat content, in smoked carp meat.

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.G. Del Moral, F. O'Valle, M. Masseroli, R.G. Del Moral, Journal of Food Engineering, **81** (2007) 33.
3. D. L. Hopkins, E. Safari, J. M. Thompson, C. R. Smith, Meat Science, **67** (2004) 269.
4. P. Pipek, J. Jelenikova, L. Sarnovsky, Czech J. Anim. Sci., **49** (3) (2004) 115.
5. C. Vienne, Central Bureau of the Comission Internationale de l'Eclairage, 2nd Ed. Publication CIE No. 115, 2.CIE (1986).
6. K. Leon, D. Mery, F. Pedreschi, J. Leon, Food Research International, **39** (10) (2006), 1084.
7. A. C. Teusdea, T. Modog, A. Mancia, Annals of DAAAM for 2008 & Proceedings of the 19th International DAAAM Symposium, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, 1381-1382 (2008).