MONITORING THE COLOUR CHANGES DURING AGING OF SALAMI BY *MIA*

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Abstract
The red colour intensity of a meat product like salami mainly depends on the relative quantity of each myoglobin oxidation state. The aim of this work was to evaluate whether MIA could monitor the colour changes occurring during the aging of salami, in comparison with the assessment of the colour coordinates (R, G, B, Intensity mean) by Image Analysis.

Keywords – Salami, Colour, Myoglobin, Multivariate Image Analysis

Introduction
In salami, the colour shifts from bright red in the fresh product to dark red in the aged salami. The colour intensity depends not only on the total myoglobin content, but also on the relative proportions of oxymyoglobin (bright red), myoglobin (red), and metmyoglobin (grey-brown) [1]. It has been in fact demonstrated that there is a relationship between the red colour intensity of the meat, measured by colorimeter or image analysis, and the oxidation state of the meat surface [2]. Many papers have been published discussing the application of Image Analysis (IA) to meat quality assessment [3]. The colour and the oxidation level on the meat surface is relatively simple to measure [2], whereas in salami the presence of fat granules creates some difficulties in color intensity assessment. The aim of this work was to evaluate the potential of Multivariate Image Analysis (MIA) to monitoring the colour changes occurring during aging of salami, comparing the results with the assessment of the R, G, B and Intensity values by IA.

Materials and Methods
- Salami samples
A total of 20 industrially-produced salami were evaluated, coming from two different batches (10 salami for each batch). Fresh salami underwent an aging

process of 20 days at 15°C. During aging, every 5 days 2 salami were evaluated.

- Image Analysis (IA) and Multivariate Image Analysis (MIA)

At each sampling time, images of 2 slices for each salami of both batches were acquired by a calibrated flatbed scanner (Epson Expr. 8000, Seiko Corp., Japan), at 300dpi and 24bit colour. During acquisition, samples were covered with a black box to prevent loss of light. A total of 40 images (saved in TIFF format) were collected. The R,G,B and Intensity values of each image were measured by IA using Image-Pro Plus v.7.0 (MediaCybernetics, Inc., USA). The same images were also subjected to MIA using the MACCMIA v.1.81 Tool for MATLAB and, for each slice, a PCA image was obtained [4,5]. These images were then processed by Image-Pro Plus, to quantify the surface occupied by each area previously identified by MIA. All the steps of MIA procedure are shown in Fig. 1.

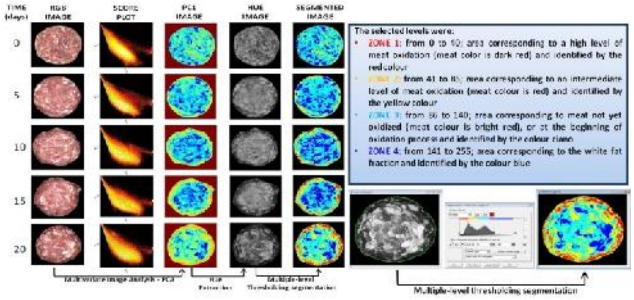

Figure 1. Steps of the Multivariate Image Analysis

Results

Colour analysis was performed on the entire surface of the salami slice, considering simultaneously the fat and lean part. The values of colour coordinates decreased during aging (Tab. 1), meaning that a shift towards a darker colour was taking place.

Table 1. R, G, B and Intensity values of salami slices measured during aging.

Time (days)	R	G	B	I
0	198.2±4.1[c]	139.1±4.8[c]	129.4±4.8[d]	155.6±4.5[d]
5	191.5±8.0[b]	130.6±6.3[b]	125.9±5.9[cd]	149.3±6.7[c]
10	189.4±6.3[ab]	126.6±5.0[ab]	123.2±5.5[bc]	146.4±5.4[bc]
15	183.6±7.0[a]	121.5±4.3[a]	117.6±4.7[a]	140.9±5.2[a]
20	185.9±4.5[ab]	124.6±5.1[a]	120.5±5.1[ab]	143.7±4.7[ab]

[a-d] Data followed by different letters in a column are significantly different ($p<0.05$).

MIA results appeared notably interesting. In the salami slice images, four different areas were identified by the mathematical model as a function of the colour intensities, corresponding respectively to the white (fat) and to three different levels of red (Fig. 2A). These three levels of red refers to the lean part that from a bright red colour became darker during the aging, in particular along the border of the slice. This phenomenon is most likely due to the physico-chemical changes occurring during aging, when the changes of the oxidation state of myoglobin play an important role. Fig. 2B evidences how the surface percentages of each zone of the slices changed during the aging process.

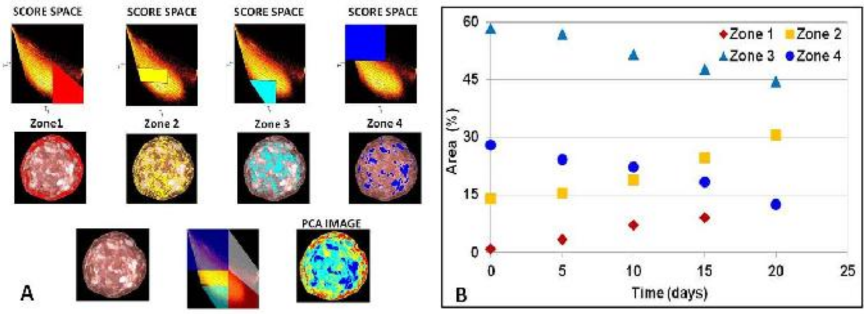

Figure 2. Pixels classification as a function of their red intensity (A); variation of the percentage of each zone of the slices during aging (B).

Conclusions

While the colour evaluation of salami in terms of R, G, B and Intensity values allows only an estimation of global colour changes in salami slices during aging, by applying MIA the colour changes are more evident and can be objectively described. In fact, fat and lean part were discriminated and the pixels of the lean part were classified as a function of their red intensity, corresponding to different oxidation states of myoglobin. The next step will be to compare the traditional methods used to assess the amount of each oxidation state of myoglobin present in the salami slices with the results obtained by MIA, eventually using hyperspectral imaging technique.

References

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