INFLUENCE OF LED-ILLUMINATION ON DISCOLOURATION AND OXYGEN UPTAKE ON CURED BOILED SAUSAGE

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Abstract – The objective of this study was to evaluate the influence of different spectral bands of light-emitting diodes (LEDs) on colour stability and oxygen uptake of illuminated, packaged cured boiled sausage. Sausage samples packed in a model packaging system were illuminated by red, green and blue one-colour LEDs as well as by white LED light, which was a mixture of red, green and blue LEDs. The irradiation of all LEDs was equal. The residual headspace oxygen in the packaging was varied between 0, 0.5 and 2% O_2. Differences in greying and oxygen uptake of the sausage were seen between varying residual oxygen content in the package and different illumination colour. The blue LED with shorter wavelength and therefore higher energetic radiation caused higher discolouration and oxidation of the sausage.

Key Words – Greying, Residual oxygen, Cured meat products

I. INTRODUCTION

Self-service packaged food is an increasing market, especially for meat and sausages. The consumers´ acceptance of sausages packaged under modified atmosphere is mainly determined by visual properties such as colour, shape and design of the product and packaging [1]. Therefore meat products are often packed in transparent packages where they are exposed to the influence of light [2]. Light in combination with residual oxygen in the package causes a discolouration of cured meat products [3]. The characteristic pink colour of cured boiled sausages, the denaturated nitrosylmyoglobin (MbNO) turns grey in the presence of oxygen and light [4]. The products in retail markets are illuminated by different light sources. A new technology of illumination in retail stores are the energy-saving LEDs. There are two different kinds of white LEDs. RGB-LEDs use individual LEDs that emit three colours - red, green and blue - a mixture of all these colours forms white light. Phosphor-based LEDs use a phosphor material to convert monochromatic light from a blue or UV-LED to white light, much in the same way a fluorescent tube works [5]. Meat products are very sensitive against light. Specific spectral bands have various influences on the colour stability and the oxygen uptake of meat products. The objective of the present study was to examine the influence of the spectral bands of RGB-LEDs with the three primary colours and their mixture resulting in white light, in combination with different oxygen contents in the headspace of packaged sausage. Therefore the effect, that primary colours can be mixed in different ways to form white light, which is detected as the same by the human retina, might be used to find a spectral parameter setting, which is less harmful to meat and meat products [6].

II. MATERIALS AND METHODS

Cured sausage of pork "Lyoner" type was manufactured at the Fraunhofer-Institut IVV in Freising, Germany with a standard recipe. The sausage was stored at 2 °C in the dark before usage. The discolouration and the oxygenation of cured sausages due to light influence were measured in special hermetic stainless steel cells with glass cover. These cells were flushed with three different gas mixtures (0 % O_2 / 100 % N_2; 0.5 % O_2 / 99.5 % N_2; 2 % O_2 / 98 % N_2) from Linde AG, Germany to simulate a gastight modified atmosphere packaging (MAP) [7]. The colour was measured as L*a*b*-values with the DigyEye measurement system from Verivide, UK and the oxygen uptake of the sausage was measured by a non-destructive fluorescence measuring instrument Fibox 3 LCD trace from PreSens - Precision Sensing GmbH , Germany at the beginning and at the end of the illuminated storage after 24 hours.

The spectral properties of the light sources were measured with a CAS 140 CT Compact Array Spectrometer from Instrument Systems, Germany.

The lamps used for this study were Stairville LED Par56 with 151 LEDs RGB controlled by a DMX controller.

Storage tests were carried out with defined oxygen concentrations in the headspace at the beginning, constant temperature (8 - 9 °C) and defined irradiance (1.85 W/m^2) over the whole storage period. For each treatment, values were performed in triplicate. Values are shown as mean with standard deviation.

III. RESULTS AND DISCUSSION

In Figure 1 the spectral curves of the different RGB-LEDs are illustrated. The used LEDs emitted only light in visible wavelengths. The white appearing LED is a mixture of the blue, green and red LEDs.

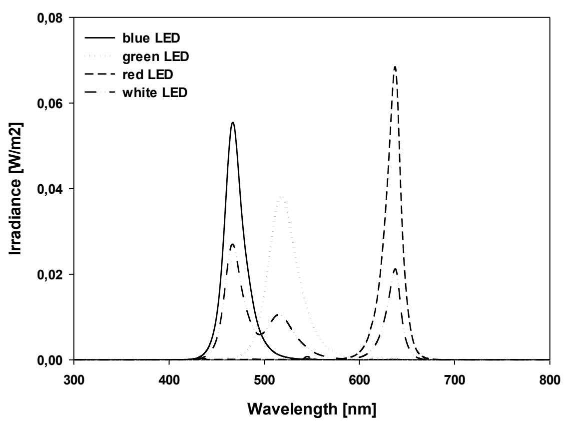

Figure 1 Combined emission spectra of blue, green, red and white LEDs [8]

For the discolouration measurement of the cured sausage the a*-value, indicating the redness of the product, was regarded.

Discolouration of the sausages increased with higher headspace oxygen content at the beginning of the storage for all illumination colours (Fig. 2). This is in accordance with other studies from Møller *et al.* [9] and Nannerup *et al.* [10]. The changes in a*-value are higher using the blue LEDs for illumination compared to the red and green lights. The white illumination caused less greying than blue illumination, but more than red and green. The differences between the illumination colours in each oxygen group are stronger with increasing headspace oxygen content.

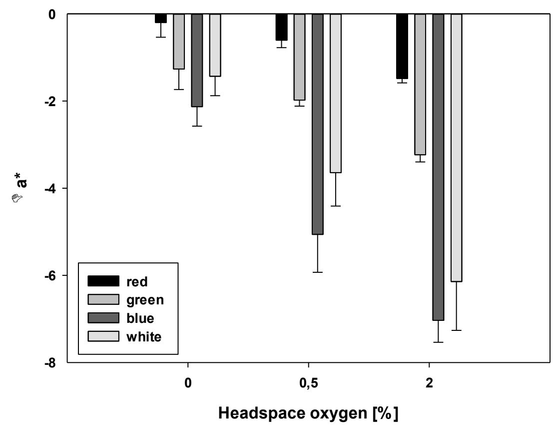

Figure 2 Changes in a*-value (mean±SD) in dependency on headspace oxygen at the beginning of the storage and the LED colour of illumination after 24 hours [8]

Figure 3 showes the changes in headspace oxygen depending on different light sources and oxygen contents at the beginning of the storage. The headspace oxygen content of the packages rose during a storage time of 24 hours in the packages which were flushed with 0 % oxygen and 100 % nitrogen. This can be explained by the diffusion of residual oxygen which is dissolved in the sausage or trapped between the packaging and the sausage into the headspace [11]. The samples flushed with 0.5 % O_2 show a rise in oxygen content of the red and green illuminated samples and a drop of the blue and white illuminated samples. The drop in headspace oxygen of the blue and white samples might be explained by the light induced oxidation of the higher energetic radiation of the blue and white light, which also leads to a higher loss in a*-value shown in the colour measurement of Fig. 2. Samples flushed with 2 % oxygen at the beginning of the test showed a stronger drop in headspace oxygen and a stronger drop in a*-value. That might be explained by a higher oxygen concentration available for light induced oxidative reactions.

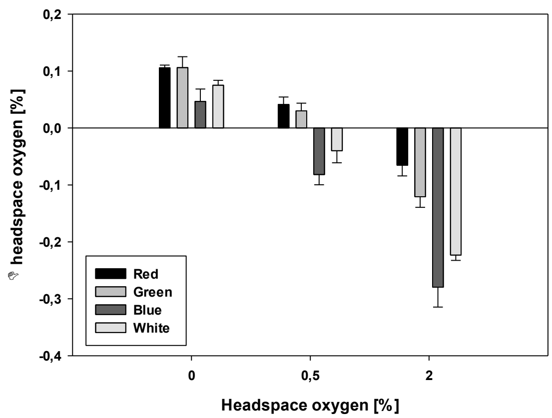

Figure 3 Changes in headspace oxygen [%] (mean±SD) in dependency on headspace oxygen concentration at the beginning of the storage and the LED colour of illumination after 24 hours [8]

IV. CONCLUSION

Greying of cured meat products is a sensitized photooxidation which is induced with light in the visible range. Blue light seems to be more harmful than green and red light.

Low residual oxygen concentrations in the headspace of packaged sausages prevent greying. The use of LEDs for retail displays is an energy-saving alternative to fluorescent tubes. The effect of metamerism [12], (primary colours can be mixed in different ways to form white light) can be used to develop LEDs for refrigerated counters and shelves, which have a little fraction of the wavelengths having a less harmful effect on cured sausages.

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REFERENCES

[1] Girolami, A., Napolitano, F., Faraone, D. & Braghieri, A. (2013). Measurement of meat color using a computer vision system. Meat Science 93(1): 111–8.

[2] Troy, D.J. & Kerry, J.P. (2010). Consumer perception and the role of science in the meat industry. Special Issue: 56th International Congress of Meat Science and Technology (56th ICoMST), 15-20 August 2010, Jeju, Korea 86(1): 214–26.

[3] Andersen, H.J., Bertelsen, G., Boegh-Soerensen, L., Shek, C.K. & Skibsted, L.H. (1988). Effect of light and packaging conditions on the colour stability of sliced ham. Meat Science 22(4): 283–92.

[4] Soltanizadeh, N. & Kadivar, M. (2012). A new, simple method for the production of meat-curing pigment under optimised conditions using response surface methodology. Meat Science 92(4): 538–47.

[5] Skibsted, L.H. (1992). Cured meat products and their oxidative stability. Special Publication-Royal Society of Chemistry 106: 266.

[6] Li, Z. & Berns, R.S. (2007). Comparison of methods of parameric correction for evaluating metamerism. Color Research & Application 32(4): 293–303.

[7] Rieblinger K., Ziegleder G., Berghammer A.& Sandmeier D. Storage characteristics measuring device for foodstuffs - measures oxygen content of residual volume in container holding foodstuff upon application of heat; patent; DE19528400-C1 (1996).

[8] Fraunhofer Institut for Process Engineering and Packaging IVV. internal results.

[9] Møller, J.K. S., Bertelsen, G. & Skibsted, L.H. (2002). Photooxidation of nitrosylmyoglobin at low oxygen pressure. Quantum yields and reaction stoechiometries. Meat Science 60(4): 421–5.

[10]Nannerup, L.D., Jakobsen, M., van den Berg, F., Jensen, J.S., Møller, J.K. S. & Bertelsen, G. (2004). Optimizing colour quality of modified atmosphere packed sliced meat products by control of critical packaging parameters. Meat Science 68(4): 577–85.

[11]Møller, J., Jensen, J., Olsen, M., Skibsted, L. & Bertelsen, G. (2000). Effect of residual oxygen on colour stability during chill storage of sliced, pasteurised ham packaged in modified atmosphere. Meat Science 54(4): 399–405.

[12]Hunt R. W.G. (2005). The reproduction of colour: Wiley.