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

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Abstract – The objective of this study was to evaluate the influence of different illumination sources on the oxygen uptake and the colour stability of cured boiled sausages. Sausage samples packed in a model packaging system were illuminated with different lights for food illumination. Daylight fluorescent tubes are the most commonly used light sources in retail markets. By using the same irradiance, comparing new light emitting diodes (LEDs), metal halide lamps and fluorescent tubes for fresh meat, the daylight fluorescent tubes showed the highest influence on oxygen uptake and greying of illuminated sausage. Samples with 0.5 % headspace oxygen content showed a drop in oxygen about 1 mg O_2/ 100 g sausage during 24 h storage under a daylight fluorescent tube. Metal halide lamps and fluorescent tube for meat products showed a smaller drop in oxygen content about 0.3 mg O_2/ 100 g sausage. Discoloration of the surface gave comparable results. Daylight fluorescent tubes showed a drop in a*-value (which indicates the redness of a product) about 8 and the metal halide lamps and the LEDs about 5. Therefore the use of special lamps for food illumination can help to prevent negative changes on illuminated sausages in retail markets.

Introduction

The consumers´ acceptance of sausages packaged under modified atmosphere is mainly determined by visual properties such as colour and design of the product and packaging. This results in the inhibition of other sensory perceptions like smelling and touching. Therefore cured sausages in self-service shelves are often offered in transparent packaging. The influence of light and oxygen leads to discolouration of cured sausages [1]. The characteristic pink colour of cured boiled sausages, the denaturated nitrosylmyoglobin (MbNO) turns grey in the presence of oxygen and light [2]. Different light sources are available on the market for food illumination. The most common commercial lamps are the fluorescent tubes. Newer and more energy-saving are the LEDs. Metal halide lamps and fluorescent tubes with a higher proportion of red especially for meat products are also in use. The colour of a product, like it is seen by a consumer in the supermarket, is determined by the spectral reflection of the product itself and furthermore by the spectral radiation distribution of the light sources [3]. Lamps for meat products often have a higher proportion of red in the visible spectrum to strengthen the perception of the attractive red colour of the meat. In the Cornet project CureColour (49 EN/1) the influence of different light sources and various residual oxygen concentrations in the packages of fresh cut cured boiled sausages is investigated.

Material and Methods

The sausage "Lyoner" type was manufactured at the Fraunhofer-Institut IVV in Freising, Germany with a standard recipe and the German "Magerbrät" process. Minced lean meat was added to the chopping bowl

(Typ 30 L 5000 Express, KILIA Fleischerei- u. Spezialmaschinenfabrik, Germany) and chopped for several minutes with curing salt, diphosphate and one third of the crushed ice until a temperature of 4 °C was reached. Next, the fat and the spices were added with another third of the crushed ice. The batter was chopped up to 8 °C, then the bowl chopper was scraped out and the rest of the ice was added. The lit of the bowl chopper was closed and the batter was chopped under 85 % vacuum until a temperature of 13-14 °C was reached. The batter was filled with a vacuum-filler (Typ VF 608 plus, Handtmann Maschinenfabrik GmbH, Germany) into impermeable fibrous casings with a caliber of 75 mm (Wiberg, Germany). The sausages were boiled in a vessel (Kochmeister, Reich, Germany) with a water temperature of 72 °C until a core temperature of 68 °C was reached.

The discolouration and the oxygenation of the sausages due to light influence was measured in special hermetic stainless steel cells with glass cover and a defined amount of oxygen in the headspace to simulate a gastight package [4]. In the sausage and also between the slices was some residual physically bounded oxygen. Therefore the samples were stored overnight in the measuring cells with 100 % nitrogen in the headspace to let the dissolved oxygen release to the headspace. Just before the measurement started, the measuring cells were flushed with a gas mixture of 99.5 % N_2 and 0.5 % O_2 for removing the released oxygen and to flush the headspace with the defined oxygen concentration.

The colour was measured as L*a*b*-values with the DigyEye measurement system from Verivide, UK. The DigyEye was calibrated with a white uniformity board and a DigiTizer Chart.

The oxygen uptake of the sausage was measured by a non-destructive fluorescence measuring instrument Fibox 3 LCD trace and an oxygen sensor spot PST6 from PreSens - Precision Sensing GmbH, Germany at the beginning and at the end (after 24 hours) of the illuminated storage.

Lamps used for this study were a fluorescent tube (OSRAM Lumilux Cool Daylight 30W/865), a fluorescent tube for fresh meat (BÄRO Basic Frischfarben-Leuchtstofflampe 30361), a metal halide lamp (PHILIPS MasterColour CDM-T Elite 35W/930 Crisp white light) and a LED (BÄRO Food Leuchtdiode).

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

Storage tests were carried out with defined oxygen concentrations in the headspace at the beginning, constant temperature (6 - 7 °C) and defined irradiance (2.70 W/m^2) during the whole storage period. For each treatment, values were performed in triplicate. Values are shown as mean with standard deviation.

Results and Discussion

In Figure 1 and 2 the spectral curves of the used lamps are illustrated. The five main spectral bands of fluorescent tubes are recognizable. The mercury of the fluorescent lamp which becomes excited by electricity produces UV-light which causes a triphosphor mixture to fluorescent. A triphosphor mixture is used to cover the whole spectrum of the visible light. Therefore peak maxima at 435 nm (blue), 490 nm (blue/green), 545 nm (green), 587 nm (yellow) and 610 nm (orange) are visible resulting in white light. Every lamp has a characteristic irradiation spectrum. LEDs (Fig. 2) emit only wavelength in the visible range and does not contain a higher energetic UV radiation and no infrared portion which could lead to higher temperatures of the products. The absorption spectrum of the cured meat pigment nitrosylmyoglobin has peak maxima at 421, 548 and 579 nm [5], therefore light of shorter wavelengths which corresponds to the absorption spectra of the cured meat pigment leads to a higher oxidation rate of the nitrosylmyoglobin [6] and consequently to the so called “greying” of cured sausages.

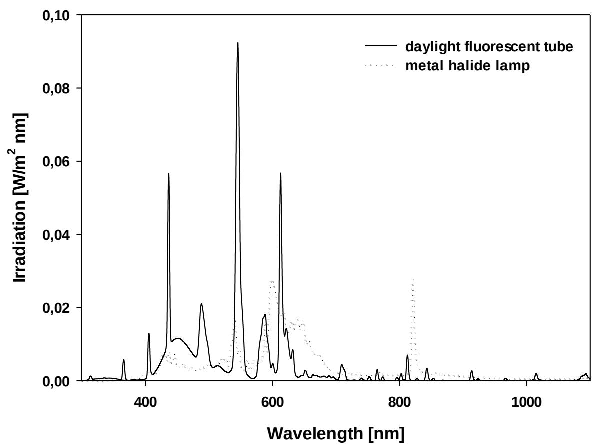

Figure 1 Irradiation spectrum of a daylight fluorescent tube and a metal halide lamp from 300 to 1100 nm [7]

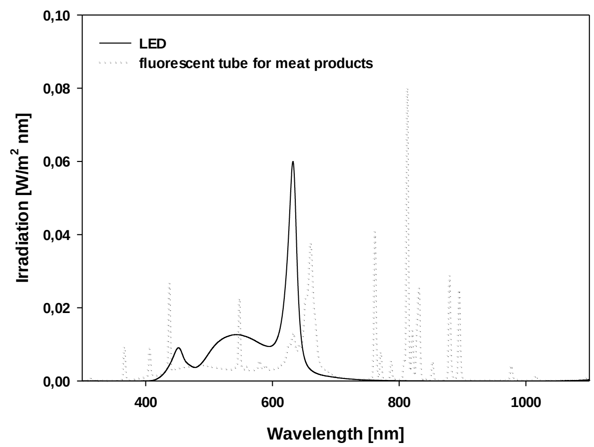

Figure 2 Irradiation spectrum of a LED and a fluorescent tube for meat products from 300 to 1100 nm [7]

Figure 3 shows the changes in headspace oxygen during 24 hours of illuminated storage of cured sausage “Lyoner”-type. The oxygen content in the headspace at the beginning was 0.5 %. During the first 8 hours no significant differences between the lamps were visible, but after 24 hours the daylight fluorescent tube shows a significant higher drop in headspace oxygen compared with the fluorescent tube for meat products and the metal halide lamp. The higher oxygenation rate of the sausages illuminated with the daylight fluorescent tube might be explained by a higher irradiation portion in the range of the absorption spectra of the nitrite-cured meat pigment nitrosylmyoglobin. This pigment by itself works as a photosensitizer [8] and leads to a deterioration of the cured meat pigment itself and also to fat oxidation [9].

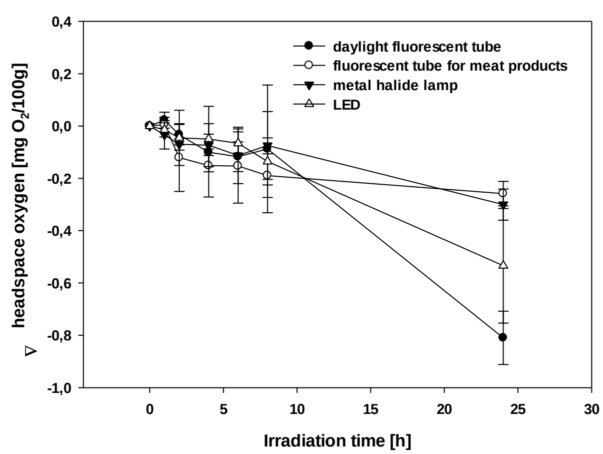

Figure 3 Changes in headspace oxygen [mg O_2/100g] during illuminated storage of 24 hours with daylight fluorescent tube, fluorescent tube for meat products, metal halide lamp and LED [7]

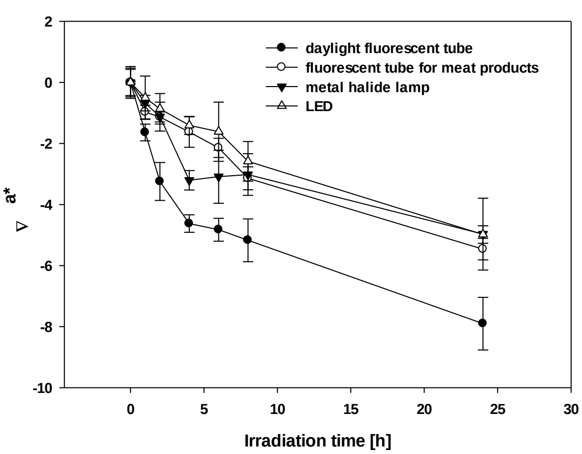

Figure 4 Changes in a*-value during illuminated storage of 24 hours with daylight fluorescent tube, fluorescent tube for meat products, metal halide lamp and LED [7]

In Fig. 4 the changes in a*-value are illustrated. After 2 hours the greying of the samples illuminated with a daylight fluorescent tube is significantly stronger than for the other lamps. After 24 hours, the a*-value of the fluorescent lamp decreased by 8 compared to the others by 4. This agrees with the higher oxygen uptake of the sausages illuminated with the daylight fluorescent tube. Carlsen et all. wrote, that a discoloration of cured meat potentially initiates oxidative rancidity of the cured products [10]. This might explain the differences between oxygen uptake and changes in a*-value. Fat oxidation was not measured in this study.

Conclusion

Greying of cured meat products is a sensitized photooxidation which is induced with light in the visible range. To prevent greying of sausages in transparent packages, it is very important, that the residual oxygen in the headspace is as low as possible. The main oxygen intake into the package is through slicing and packaging. Slicing and packaging under nitrogen atmosphere would also prevent the oxygen intake into the package through this process steps and therefore the colour retention of the sausage. The use of special lamps for food illumination is also an alternative to preserve the typically pink colour and therefore the quality of cured meat products in retail outlets.

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