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Colour calibration of a laboratory computer vision system for quality evaluation of pre-sliced hams

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ABSTRACT

Due to the high variability and complex colour distribution in meats and meat products, the colour signal calibration of any computer vision system used for colour quality evaluations, represents an essential condition for objective and consistent analyses. This paper compares two methods for CIE colour characterization using a computer vision system (CVS) based on digital photography; namely the polynomial transform procedure and the transform proposed by the sRGB standard. Also, it presents a procedure for evaluating the colour appearance and presence of pores and fat-connective tissue on pre-sliced hams made from pork, turkey and chicken. Our results showed high precision, in colour matching, for device characterization when the polynomial transform was used to match the CIE tristimulus values in comparison with the sRGB standard approach as indicated by their ΔE^*_{ab} values. The [3 × 20] polynomial transfer matrix yielded a modelling accuracy averaging below 2.2 ΔE^*_{ab} units. Using the sRGB transform, high variability was appreciated among the computed ΔE^*_{ab} (8.8 ± 4.2). The calibrated laboratory CVS, implemented with a low-cost digital camera, exhibited reproducible colour signals in a wide range of colours capable of pinpointing regions-of-interest and allowed the extraction of quantitative information from the overall ham slice surface with high accuracy. The extracted colour and morphological features showed potential for characterizing the appearance of ham slice surfaces. CVS is a tool that can objectively specify colour and appearance properties of non-uniformly coloured commercial ham slices.
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1. Introduction

Over the last decade, an explosive growth has been witnessed in both the diversity of techniques and the range of applications regarding food image analysis, which is capable of extracting from food surfaces various image features such as colour, image texture, shape, and size among others (Zheng, Sun, & Zheng, 2006). These simple appearance features have allowed task-relevant analysis and interpretation with precision, objectivity and speed in the quality grading and classification of many foods. In fact, these appearance properties correlate well with many physical, chemical, and sensory indicators of food quality (Hutchings, Luo, & Ji, 2002). Consequently, they could also be used for the automation of ham inspection and quality grading, through the incorporation of efficient image processing algorithms in industrial computer vision systems (CVS).

In the pork industry, colour is considered one of the most important quality parameters of meats, and particularly because it helps in the identification of PSE (pale, soft, exudative) meats (Tan, 2004). Colour is a very important factor, as a sensory characteristic, affecting the prices of raw carcasses and the final quality of processed products, and it is immediately noticed by consumers determining acceptance or rejection (Adorni, Bianchi, & Cagnoni, 1998). Ham products are produced in large scale and consumed worldwide. However, it should be noted that the term 'ham' in some countries refers only to pork; nevertheless it is used worldwide for countless meat products, where brine is added to smaller pieces of meat (Feiner, 2006). CVS is important to the modern ham manufacturing process, because the quality evaluation and grading requirements have moved beyond the limits of human inspection. In the processing plants, the manufactured items often are produced too quickly and with product tolerances too small to be analyzed by human inspection protocols. Moreover, methods for assessing the quality of ham products, either by sensory analysis or by instrumental techniques, are frequently destructive and time-consuming, and therefore, they do not fit the conditions for a routine online analysis in an industrial environment. The ham industry is interested in an instrument that assesses the colour of the whole ham slice. In this sense, digital image analysis is a non-destructive tool that has interesting applications for the overall surface characterization and quality inspection of pre-sliced hams (Zheng et al., 2006). Computerized image analysis techniques

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