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Characterization of fat-connective tissue size distribution in pre-sliced pork hams using multifractal analysis

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ABSTRACT

Fat-connective tissue size distribution (FSD) in hams is a fundamental physical property for its quality assessment. FSD is related to the sensory properties such as texture, taste, quality of raw meat and visual appearance. In this paper we present a tool to carry out the multifractal analysis (MFA) of two-dimensional binary images of pre-sliced pork hams through the calculation of the $f(\alpha)$-spectra, Rényi (D_q) dimensions, and associated statistical regressions and parameters. The application is presented for the structural characterization of FSD in three qualities of pork hams (high yield, medium yield and premium quality hams) using image sections of 512×512 pixels^2 with a spatial resolution of 0.102 mm/pixel. MFA was carried out using the method of moments in the optimized box size range of 32–512 pixels for all the ham images using powers of 2, and estimating the probability distribution for moments ranging from $-10 < q < 10$ in steps of 0.5. The experimental results suggest that MFA has a discriminating effect among the three types of ham using the maximum entropy (H^*_{max}) and correlation dimension D_2. This investigation revealed the usefulness of the MFA dimensions as quantitative descriptors of texture analysis and pattern distributions of FSD in pre-sliced ham images.

1. Introduction

1.1. Fat-connective tissue in pork hams

An essential component of meat and meat products is their fat content. In general, the fat content must be controlled and guaranteed for a wide range of processed products such as hams, ground beef, hamburgers, sausages and pâté (Brienne, Denoyelle, Baussart, & Daudin, 2001). Traditionally, the estimation of ham composition mainly relies on human visual inspection based on the perception of the area of fat and lean muscle at the ham cutting faces. The grading or sorting is usually based on the weight estimation of these areas. This assessment method is inconsistent due to many factors, such as personal bias and inspection environment, which could directly affect the decision making of human inspectors (Jia, Schinckel, & Forrest, 1995). On the other hand, chemical analysis is the most frequently used method to objectively determine the intramuscular fat level in meats and meat products, but this technique is expensive, destructive and tedious. The use of non-destructive physical measurements for the rapid characterization of the composition of raw materials and end-products is essential in order for the meat industry to improve their quality. Nonetheless, manufacturing processes which involve grinding and mixing of raw materials have highly variable fat-connective tissue/lean compositions making standardization and control tasks difficult.

Computer vision technology has been implemented for quality assessment in meats and meat products, overcoming most of the drawbacks of traditional methods, e.g. human inspectors and instrumental techniques (Du & Sun, 2005, 2006; Zheng, Sun, & Zheng, 2006; Zheng, Sun, & Tan, 2008; Kumar & Mittal, 2009; Quevedo, Aguilera, & Pedreschi, 2009; Quevedo & Aguilera, 2009). Image analysis techniques are capable of performing objective measurements not only of colour, defects, image texture, etc., related to the visual appearance (Kaya, Ko, & Gunasekaran, 2008; Kumar & Mittal, 2008; Fathi, Mohebbi, & Razavi, 2009) but also of quantifying colour and textural patterns from food surfaces, which cannot be detected by human vision (Mendoza et al., 2009; Valous, Mendoza, Sun, & Allen, 2009a). Textural patterns in natural objects are often complex, exhibit scale-dependent changes in structure, and are difficult to identify and describe by simple visual inspection (Plotnick, Gardner, Hargrove, Prestegaard, & Perlmutter, 1996).

In ham products, the fat-connective tissue size distribution (FSD) represents a fundamental physical property used for quality assessment purposes. FSD is related to sensory properties such as

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