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Detecting fractal power-law long-range dependence in pre-sliced cooked pork ham surface intensity patterns using Detrended Fluctuation Analysis

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ABSTRACT

The visual texture of pork ham slices reveals information about the different qualities and perceived image heterogeneity, which is encapsulated as spatial variations in geometry and spectral characteristics. Detrended Fluctuation Analysis (DFA) detects long-range correlations in nonstationary spatial sequences, by a self-similarity scaling exponent α. In the current work, the aim is to investigate the usefulness of α, using different colour channels (R, G, B, L*, a*, b*, H, S, V, and Grey), as a quantitative descriptor of visual texture in sliced ham surface patterns for the detection of long-range correlations in unidimensional spatial series of greyscale intensity pixel values at 0°, 30°, 45°, 60°, and 90° rotations. Images were acquired from three qualities of pre-sliced pork ham, typically consumed in Ireland (200 slices per quality). Results indicated that the DFA approach can be used to characterize and quantify the textural appearance of the three ham qualities, for different image orientations, with a global scaling exponent. The spatial series extracted from the ham images display long-range dependence, indicating an average behaviour around 1/*f*-noise. Results indicate that α has a universal character in quantifying the visual texture of ham surface intensity patterns, with no considerable crossovers that alter the behaviour of the fluctuations. Fractal correlation properties can thus be a useful metric for capturing information embedded in the visual texture of hams.

1. Introduction

1.1. Characteristics of cooked pork hams

Hams are usually cuts of pork that come from the hind leg and may be cooked or served fresh, although most of them are cured in some fashion (Feiner, 2006). Wet-cured cooked hams are subjected to a temperature high enough to coagulate the meat proteins. Cooking affects the structure of the meat proteins and as a consequence the number of intra and intermolecular bonds increases. This provides stability to the muscular tissue and facilitates slicing (Katsaras & Budras, 1993). Final product quality depends both on the raw material used and processing conditions, which includes injection of brine, tumbling and cooking. The brine injection level and the ingredients used determine the quality of the ham (Casiraghi, Alamprese, & Pompei, 2007).

Textural patterns are often complex, exhibit scale-dependent changes in structure and are difficult to identify and describe (Plotnick, Gardner, Hargrove, Prestegaard & Perlmutter, 1996). Many natural textures do not contain any detectable periodic or quasiperiodic structure, but instead they exhibit random but persistent patterns that result in a cloud-like texture appearance (Alvarez-Ramirez, Rodriguez, Cervantes & Echeverria, 2006). The visual texture of pork ham slices reveals a great deal of information about the different qualities and the perceived image heterogeneity, which is encapsulated as spatial variations in geometry and spectral characteristics that occur on a smaller scale. The perceived variations are due to spatial dissimilarities in directional or spectral scattering characteristics, and to the distribution of pores/defects and fat-connective tissue. Ham slice surfaces are spectrally and spatially complex, exhibiting random patterns and consisting of structures of both coarse and fine resolutions (Mendoza, Valous, Allen, Kenny, Ward et al., 2009). Colour and textural features as well as spatial features, such as shape and distribution of pores/defects and fat-connective tissue, contribute to the complexity of texture appearance.

1.2. Quantification of fractal fluctuations

An important goal for the characterization of visual texture is the quantification of spatial patterns, and image analysis techniques (Schlüter, Foerster, Geyer, Knorr & Herppich, 2009; Mizrach, Lu & Rubino, 2009; Kumar & Mittal, 2009; Valous, Mendoza, & Sun, 2010a; Pallottino, Menesatti, Costa, Paglia, De Salvador et al., 2010; Fathi, Mohebbi & Razavi,

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