



Analysis and classification of commercial ham slice images using directional fractal dimension features

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ABSTRACT

This paper presents a novel and non-destructive approach to the appearance characterization and classification of commercial pork, turkey and chicken ham slices. Ham slice images were modelled using directional fractal (DF_{0°,45°,90°,135°}) dimensions and a minimum distance classifier was adopted to perform the classification task. Also, the role of different colour spaces and the resolution level of the images on DF analysis were investigated. This approach was applied to 480 wafer thin ham slices from four types of hams (120 slices per type): i.e., pork (cooked and smoked), turkey (smoked) and chicken (roasted). DF features were extracted from digitalized intensity images in greyscale, and *R*, *G*, *B*, *L**, *a**, *b**, *H*, *S*, and *V* colour components for three image resolution levels (100%, 50%, and 25%). Simulation results show that in spite of the complexity and high variability in colour and texture appearance, the modelling of ham slice images with DF dimensions allows the capture of differentiating textural features between the four commercial ham types. Independent DF features entail better discrimination than that using the average of four directions. However, DF dimensions reveal a high sensitivity to colour channel, orientation and image resolution for the fractal analysis. The classification accuracy using six DF dimension features (*a*_{90°}, *a*_{135°}, *H*_{0°}, *H*_{45°}, *S*_{0°}, *H*_{90°}) was 93.9% for training data and 82.2% for testing data.

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1. Introduction

The term 'ham' means cuts of pork that come from the hind leg of a hog, which may be fresh, dry cured (country hams) or wet-cured (city hams) and then boiled or smoked. However, in the trade, a variety of hams made from countless meat products can be found that are cured and smoked by different methods (Feiner, 2006). Thus, hams made from the front leg of a hog or shoulder are called 'picnic or sandwich hams' and they are ready-to-eat when purchased. The picnic hams are more economical but contain more internal fat than the blade shoulder and are less tender in texture. Other varieties such as the 'turkey' and 'chicken' hams, which could also be considered picnic hams, are made from the thigh or breast meat of these birds. These hams are frequently cooked, smoked, and roasted in combination with a variety of curing brine solutions or dry-cure mixtures of salt and other ingredients to produce more attractive products in colour, flavour and tenderness (USDA, 2007).

Although picnic hams are considered inexpensive substitutes for regular hams, the production and commercialization of thin ham slices made particularly from pork, turkey and poultry is

now going through its most significant increase as demanded by the industry and consumers for catering, delicatessen, and ingredient usage. Accordingly, quality inspection based on the identification of objective methods and quality features of these products becomes increasingly important to the pre-sliced ham product manufacturers (Becker, 2002).

In the pork industry, colour is considered one of the most important quality parameters in the identification of PSE (pale, soft, exudative) meats, since they define the price of raw carcasses and also the final quality of processed products, like pre-sliced hams (Adorni, Bianchi, & Cagnoni, 1998). In the local store, however, the main quality parameters of pre-sliced hams influencing acceptability and buying decision of consumers are not only an attractive and stable colour of the ham, but also the amount and size distribution of other appearance features such as pores (Du & Sun, 2006), marbling or fat-connective tissue (Sánchez, Albarracín, Grau, Ricolfe, & Barat, 2008), which frequently define the textural appearance of these samples. It is well known that consumers need first to be entirely satisfied with the sensory properties of the food product, before other quality dimensions become relevant (Chambers & Bowers, 1993; Giusti, Bignetti, & Cannella, 2008).

Being a non-destructive, rapid, and objective quality evaluation tool, computer vision (CV) techniques have been introduced for quality assessment and measurement of meats and their related

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