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Comparative study of transform-based image texture analysis for the evaluation of banana quality using an optical backscattering system

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ABSTRACT

In this study, the application of a backscattering imaging system with different approaches of transform-based image texture analysis for the evaluation of banana quality at different ripening stages was investigated with Wavelet, Gabor and Tamura transforms. The attenuated images of the fruits were acquired using Laser Light Backscattering Imaging (LLBI) with laser diodes emitting light at three wavelengths viz 532, 660, and 830 nm. The elasticity, chlorophyll index and soluble solids content (SSC) of each sample were measured as reference parameters by using a texture analyser, a Delta Absorbance (DA) meter, and a refractometer, respectively. The performance of the extracted features from the selected transform-based image texture analysis for analysing the quality parameters of the fruit was evaluated by means of an artificial neural network (ANN) and a support vector machine (SVM). The results indicated that there were significant changes of elasticity, chlorophyll index and SSC as the ripening stages increased. Prediction model analysis showed that the Wavelet transform exhibited the most reliable results for all of the reference parameters followed by Tamura and the Gabor transform. The results also revealed that analysis using an ANN approach recorded better performance than SVM as reflected by higher coefficient of determination (R^2) values. Thus, this study indicated that an LLBI system with transform-based image texture analysis coupled with computational intelligence techniques can be used for the evaluation of the quality of bananas.

1. Introduction

Growing awareness of the quality of fruit has necessitated increasing effort to develop rapid and non-destructive methods for evaluating fruit quality. Fresh fruit quality has been defined as the sum total of a number of attributes, properties, or characteristics that enhance or make the fruit attractive for human consumption (Achilleas and Anastasios, 2008; Giusti et al., 2008; Schreiner et al., 2013). The quantification of fruit quality parameters has depended on various destructive techniques that require the removal of a small quantities of fruit tissue, for example, the measurement of soluble solids content (SSC), total acidity, and nutritional content (Hoehn et al., 2003; Liu et al., 2010; Wold et al., 2004). These techniques offer several disadvantages such as resulting in a large amount of postharvest losses, the inability of the system to measure the whole production batch as well as being laborious and involving many more man-hours to carry out such tests.

Over the last decade, several attempts have been made in order to find the most efficient method to replace the destructive techniques. Appreciating the potential of spectral analysis in determining fruit quality, Lu (2004) combined computer vision and spectral readings with a laser diode light source to develop a spatially resolved technique to produce backscattered images. Based on the light source and the imaging unit used, the technique can be divided into three categories, namely laser light (monochromatic) backscattering imaging (LLBI), multispectral backscattering imaging (MBI) and hyperspectral backscattering imaging (HBI) (Adebayo et al., 2016a). The technique relies on the interaction of light and fruit tissue, as well as absorption and scattering properties that carries important information concerning the fruit quality. The absorption coefficient in the visible and near-infrared (NIR) range is reported to be related to the chemical composition of the fruit such as chlorophyll and SSC, while scattering is related to the microstructure properties such as fruit density, cell size, middle lamella, intra- and extracellular matrices (McGlone et al., 1997; Nicolai et al., 2007; Qin and Lu, 2008). The technique has provided promising results in the detection of many fruit qualities such as the determination of the ripening stages and chilling injury in bananas (Adebayo et al., 2016b; Hashim et al., 2014, 2013). This also includes the firmness and elastic

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