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Review

# The application of internal grading system technologies for agricultural products – Review

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ABSTRACT

Quality assessment of agricultural products has been the subject of numerous reviews; however, not many papers address internal visualization as a means of quality grading. This paper reviews established as well as emerging visualization techniques utilized in the quality assessment of food products. In this discourse, the authors set out to underscore some of the most novel signal processing techniques employed in the non-destructive grading of agricultural products by way of an automated quality verification system. Such systems utilize advanced engineering principles with imaging, signal processing as well as color differentiation to accomplish the grading task. The materials presented will be useful to agricultural engineers, manufacturing engineers, food engineers and any other researchers in the food and agriculture industries.



**Contents**



## 1. Introduction

Agricultural product quality grading is based on two inspection types namely; agricultural external grading systems which have been reviewed previously by Alfatni et al. (2011) and agricultural product grading based on internal quality assessment which has gained untold prominence in the recent past. Although traditional techniques have been employed since long before, they are greatly tedious, costly and time consuming. The previously used systems are also thought to suffer severely from subjective inferences leading to inconsistencies (García-Ramos et al., 2005). Even where this system is regarded as unbiased, the system fails to support the large-scale production requirements of our current time. It is against this background that high-technology solutions are being sought to make use of machine vision for quality, timely assess-

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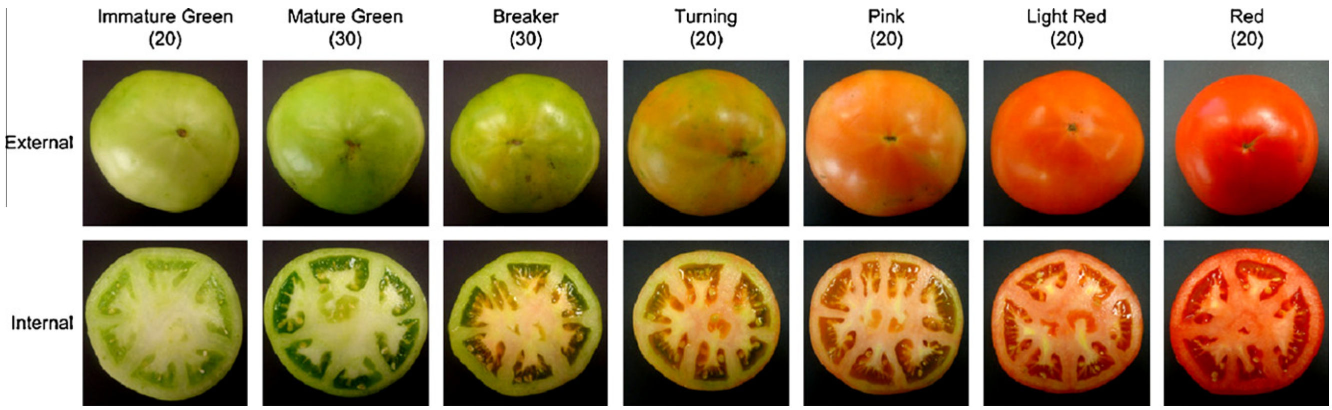


**Fig. 1.** Internal and external of tomato fruit samples at different ripeness stages (Qin et al., 2012).

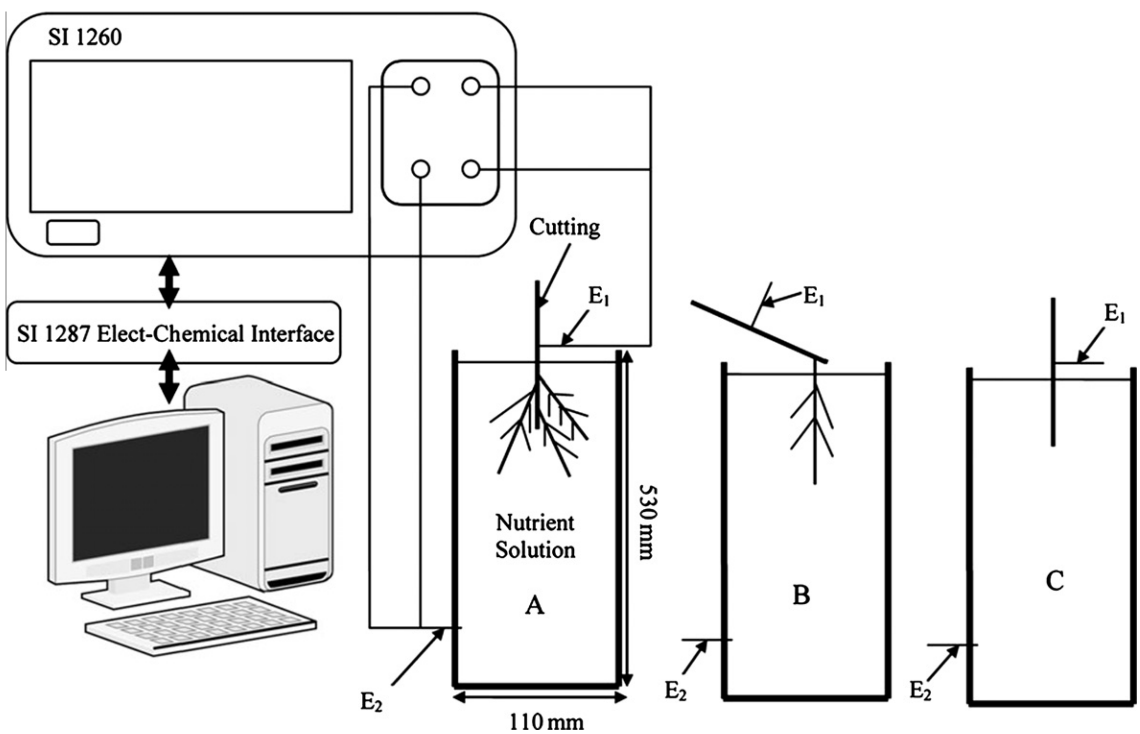


**Fig. 2.** Diagram of the experimental set-ups for the measurement of the impedance spectra of willows. (A) The stem with the whole root system in the solution ('Stem and root'). (B) A single root in the solution ('Root'). (C) The stem only in the solution ('Stem'). E1 and E2 refer to the Ag electrodes (Cao et al., 2010).

ment and accurate grading of agro-based products (Malamasa et al., 2003). This technology is suitable to perform surface or sub-surface imaging due to the limited penetration depth of the interrogating source. The recent past witnessed a mass innovation of newly developed automated internal grading solutions by researchers around the world (Alfatni et al., 2008; Leemans and Destain, 2004; Njoroge et al., 2002).

Such a system is composed of a PC with the required operating system (OS) and programming language (PL) installed and fitted to special sensors to read such internal characteristics as moisture content, sugar level etc. (Abdullah et al., 2004; Brezmes et al., 2000; Jaren and Garcia-Pardo, 2002; Kwak et al., 2007). Based on these metrics, the system sorts the products into different grades based on all other factors involved, some of which we shall relate.

## 2. Internal grading system

Fruit quality is related to both internal (firmness, sugar content, acid content and internal defects) and external (shape, size, external defects and damage) variables (García-Ramos et al., 2005). Fruit internal grading is one of the quality grading systems used in agricultural research as illustrated in Fig. 1 (Qin et al., 2012). Internal characteristics such as moisture, sugar, acidity and the like offer valuable information about fruit ripeness, which may not be easily detected by merely examining the fruit's external characteristics. Njoroge et al. (2002) devised an automated quality verification technique via the internal inspection of agricultural products using special sensors for sugar and acid content estimations. They incorporated an X-ray sensor to detect possible biological defects. An analysis of the willow root system by electrical impedance (EI) spectroscopy (EIS), as shown in Fig. 2, was conducted by Cao et al. (2010). EIS was proven to be a valuable, nondestructive method for root surface area assessment. This technique could be considered a novel methodological contribution to facilitate further understanding of root systems and their functions in a nondestructive manner. The sensor plays an integral role in the algorithm (Du and Sun, 2004). Internal constructions are not easy to detect through comparatively simple and traditional imaging means,