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Potential application of spectroscopic method for size and shape detection fruits: A review

S.S.R.M Lazim[a], and N.M. Nawi

Department of Biological and Agricultural Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Selangor, Malaysia.

Abstract

Size, shape, color and absence of visual defects are among the parameters used to define a quality level of the fruits. In agriculture, size of the products becomes major benchmark by customers to buy vegetables and fruits. This crops physical always related to the product's quality. The size and shape of agricultural products are most assessed by experienced operators. However, this conventional technique is inconsistent, subjective and time consuming. Numerous studies have been conducted to non-destructively measure the size and shape of agricultural products non-by using machine vision, acoustics and nuclear magnetic resonance (NMR).Lately, spectroscopy has been explored as an interesting alternative method to solve this problem because of its good rapidity, high consistency and suitable for routine analysis. Therefore, this review discusses the potential of spectroscopic method to determine the size of agricultural products.

Keywords: spectroscopy, size, agricultural product, non-destructive

INTRODUCTION

Qualitative evaluation of fruits has been a subject of interest to researchers for many decades. However, the definition of fruits quality is varies among researchers. There is no clear definition of quality for fruits (Chen et al., 1991). However, the physical properties including size, shape, color, and texture are common basic factors for fruit grading (Omid, 2010). These properties are among of the most the important parameters in determining the customers' acceptance. In agricultural industry, the fruit grading is done manually which involves human visual inspection. However, this practice is subjective and may lead to bias because it depends on the individual performance evaluation but, this practice is time-consuming, inefficient, and inconsistent.

The application of spectroscopy in agriculture has increased widely in recent days. In agricultural field, spectroscopy is widely used in determining the quality of agricultural products such as fruits, tea, spices, and vegetables. Norris (1964) was first who discovered the application of spectroscopy to determine the moisture content in grain. Since then, many other applications have followed for rapid analysis of internal quality especially in agricultural and food non-destructively (Davies and Grant, 1987; Gunasekaran and Irudayaraj, 2001).

In post-harvest technology, the important of spectroscopy has increased significantly from the recent increase in the number of publications (Nicolia et al., 2007). The objective of this review is to give comprehensive overview of spectroscopy application for detecting size of fruits. This technique could give an alternative to replace the traditional method in determine the size and shape of the fruits.

[a] Email: sariparabiahmatlazim@gmail.com

THE IMPORTANT OF SIZE AND VOLUME DETERMINATION OF AGRICULTURAL PRODUCTS

Size is the most important parameter in the industry in classifying the quality of the fruits. This is because the size always related their price (Sergio et al., 2011). Volume, weight and diameter are the parameters used to describe the fruit size. In the non-destructive technology, volume becomes a main indicator of index ripeness. Hahn and Sanches (2000) used these parameters to predict optimum harvest time and Mitchell (1986) used predict the yield of products. Other than that, Ngouajio et al. (2003) investigated the relationship between rate of expansion and susceptibility to physiological disorder such as fruit cracking.

The determination of fruit size is important in postharvest operations. This is because:

1. Fruit is graded according to size group. This is an indicator to determine market place and price of the products. Other than that, these parameters give a level of customers' acceptance or rejection.
2. Determination of size is compulsory for on-line fruit density sorting. There are two main reasons for sorting fruit based on density. Firstly, soluble solid content and fruit density are correlated (Sugiura et al., 2001; John and Clark, 2004). Secondly is determination of density is essential for separating of fruits. For example, watermelons with a high degree of hollowness (Kato, 1997) and internal damage of fruit which cause by insect (Forbes et al., 1999).
3. To produce surface area, size measurement is very important. Some sensors required details information to determine fruit size. The height of sensor need to adjust to cover the size of fruit.
4. In food industry, grading the fruit into a certain size is required to meet the requirement of the machine in order to undergo the process of the differentiation of small and large size of product.

NONDESTRUCTIVE TECHNIQUE FOR AGRICULTURAL PRODUCTS

Acoustic technology

The acoustic respond method was discovered by Clarke and Mikelson (1942). This measurement is based on the sound emitted by fruits. When the fruits emitted sound, a gentle tap with a small rod or pendulum will vibrates. Microphone captured the signal and Fast Fourier Ttransform (FFT) calculated the frequency of vibration. Theoretically, the resonant frequency depends on geometry, mass and modulus of elasticity of the material. A mathematical model for the interpretation of the vibrational behavior of intact fruit was proposed by Cooke and Rand (1973).

Young's modulus or elastic modulus can be determined by density and mass. The matured and ripen of the fruit, modulus elasticity changes from 5 Mpa to 0.5MPa from unripe green apple to overripe of green apple (Baerdemaeker 1989; Duprat et al., 1997). This technology also applied in determination of melon ripeness.

In order to detect of the shape of fruits, this device has three main parameters which are microphone, gain, ticking power and frequency range. The tick power versus microphone gain is the main important parameters. During handling this device, the height of the scan in the ticking waveform must fit easily and ensured that the signal was not clipping. The aim of this technique is to develop the Fast Fouried Transforms (FFT) which collected by simple microphone and converted into frequency distribution in milliseconds.

Although this technique was applied successfully in determination the quality of the fruit based on shape detection, interpreting the data remain problems. This problem occurs when interpreting the variability of fruit shape (Jancsók et al., 1998).

Computer Vision technology

Computer vision also known as computer image processing or machine vision is the science that develops the theoretical and algorithm basis by which useful information about

an object which extracted from an observed image. This technique is widely used in food industry especially on examination of fruits and vegetables. The example of application of machine vision including grading, quality evaluation from external parameters or internal parameters, monitoring of fruit processes during storage since it is more reliable and objective than human inspection. Commonly, the features of the product such as color, size, shape, texture and presence of the damage are the parameters of interest in controlling quality agricultural products.

There are a lot of researches have been done on detecting the quality of the fruit based on machine vision. Leemans et al. (2001) use this technology to grade the apples into four classes according to European standard, while, Sudhakara et al. (2009) develop a model for on-line sorting for apple based on color, size and shape. Wang et al. (2009) evaluated the banana fruit based on color, Sadrnia et al. (2007) have determined the shape of watermelon and Ohali et al. (2011) has developed a prototype computer vision based on size, shape intensity and defects.

The computer vision is an automated inspection of agricultural simplify tedious in monitoring process. However, it takes a long time and requires complex apparatus to perform the task. Furthermore, the analysis of digital image requires specialized and expensive software to successfully process the image. Sometimes color is not the most suitable parameters to be assessed. As for example, it becomes complicated to differentiate the fruits and leaves of citrus fruit on the tree because both of them have the same color.

Nuclear magnetic resonance (NMR) technology

Nuclear magnetic resonance or commonly known as magnetic resonance imaging (MRI) technology has the potential for detecting size and shape of agricultural products. MRI involves high magnetic field to objects in its exact or isocentre. A strong magnetic field is applied with the presence of water in fruits and vegetables for monitoring the information of spatial distribution of proton density, relaxation and self-diffusional parameters inside the sample (Barrie et al., 2010).

MRI is used to differentiate the component in biological materials such as water, fat, oil or salt. So, MRI technology makes it attractive for scanning intact fruit and vegetable. The physical properties such as size, shape and volume and has been correlated well with firmness, soluble solid can be measured by MRI technique (Abbott et al., 1997; Clark et al., 1997). The relationship between density and internal quality of watermelon also could be estimated by multiple regression analysis with mass was investigated by Kato (1997).

MRI technology has been used successfully to detect size and shape of agricultural products, but the use of MRI technique is limited. This is because of the expensive equipment and low speed of capturing image in the past years (Clark et al., 1997).

CONCLUSIONS

The following conclusions can be drawn from the study:

- This paper has reviewed several potential technologies based spectroscopic to measure the quality of fruits and vegetable and it focuses on several technologies including acoustic, computer vision and nuclear magnetic resonance (NMR) technologies.
- Each technology has its own advantages and disadvantages.
- The instrument used in acoustic technology is simple and cheap, and this technology can be used in detection of size and shape of agricultural products, however they need invasive detection which limits the speed of detection.
- MRI technique was an excellent method to detect the size and shape of agricultural product, but the use of this technology is not practical for routine testing.
- The instrument of this technology is more expensive than those for other technologies, difficult to operate and low speed of capturing image.
- The grading system for agricultural products also has been developed by

computer vision technology. This technology is consistent, efficient and commonly used in agricultural product in determining of physical properties.
- However, this technique needs a complex apparatus to perform the task.
- Sometimes color is not suitable parameters to be a benchmark in detecting the size and shape of agricultural products.
- An artificial lighting needed for dim or dark conditions to make sure this technique can perform very well.
- Spectroscopy technology has been paid more attention by researchers in recent years. Spectroscopy technique is the powerful method to detect the shape and size of agricultural products.
- It has a lot of advantages such as nondestructive and non-invasive detection, requiring no sample preparation and fast measurement.
- This spectroscopy attracts more attention from researcher because the price of these spectrometers is much lower than other technologies.
- And these spectrometers are robust and highly-insensitive to external conditions like temperature, noise, and humidity also these spectrometers combined optical fiber can be used for on-line detection.
- Spectroscopy plays an important role in the further research of on-line destructive techniques.
- Spectroscopy has great potential for evaluating the feature of agricultural products if it explores more.

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