ORIGINAL ARTICLE

Fractal box-counting technique for shelf life study of grapes by laser speckle image processing

R. Balamurugan[1], R. Sengodan[1], T. Sathish Kumar T[2], G. Cashlin Anna Suveetha[2]

[1]Department of Science and Humanities (Physics), Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India, [2]Department of Biotechnology, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India

Abstract

Background: In agriculture, it is essential to follow the ripening of fruits and vegetables which is a subject of interest economically. The use of optical non-destructive method is the most suitable technique for evaluating the ripening stage of fruits when they ripen off-tree and eventually to predict the optimum storage life. Many methods are recently developed in optical image processing. The texture correlation function and the fractal box counting (FBC) of biospeckle pattern have been described. **Materials and Methods:** The dynamic speckle patterns known as boiling speckle are produced by a coherent light illumination incident on the active material of biological tissue. A high coherent laser source He-Ne with 632 nm with neutral density filter and charge-coupled device camera are the major components of the experimental setup. The same experiment may be done by a green laser of wavelength 541 nm (green color). The same procedure continues to take the speckle images in periodically. **Results and Discussion:** With the help of FBC method in image processing technique, we can assess optically rough surface fruits such as grapes in this work. According to the FBC theory, the speckle images (R1) give a binary counting value D = 1.7640 at the initial stage. Gray image converted into binary image which gives the fractal counting value D = 1.7554 at later on phase. It means that the specimen (grapes) becomes dry periodically and its value is affected by the surrounding environmental condition. **Conclusion:** Using the dynamic speckle phenomenon or biospeckle method, we demonstrated the assessment of shelf life activity of grapes. The visual phase of the autocorrelation function gives reliable results showing the variation in activity because of the internal changes caused by decreasing water content and then becomes dry grape stage. The correlation function of speckle patternand the Fractal Box Counting (FBC) technique has been proposed as a tool to estimate the postharvest stage of grapes. The bioactivities of fruits and vegetable materials are based on Brownian motion, due to subcellular organs. This indicates the senescence or biological aging characteristics. The quantification of the biospeckle phenomena is associated with the moment of inertia, time history of speckle pattern and grey level co-occurrence matrix. We proposed a new FBC technique to assess the shelf life of grapes.

Key words: Aging of fruits, fractal box counting, laser, time history of speckle pattern

INTRODUCTION

Fruits and vegetables natural color, weight, and texture are changed due to the aging effect, particularly after harvesting. The quality of the original content of fruits can be maintain in cold storage for some short span of time. It is necessary and also socioeconomical responsibility for providing the food products in terms of safety, health, appearance, and many other market attributes. The dynamic speckle pattern is also known as boiling speckle. It is developed by a coherent light of laser illuminated on the specimen of biological tissue.[1] Hard surface fruits difficult to peel are also showing a biospeckle activity.

Address for correspondence:
R. Balamurugan, Department of Science and Humanities (Physics), Kumaraguru College of technology, Coimbatore, Tamil Nadu, India.
Phone: +91-04222661100.
E-mail: balamurugan.r.sci@kct.ac.in

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This gives the information about the maturity, turgor, damage, aging, and mechanical properties.[2,3] The growing interest in machine-based tests is focused on areas such as laser instrumentation with its ability to implement non-destructive and automated evaluations. Besides food analyses such as those performed on fruits, seeds, biscuits, ice cream, and biological films, it is important to note the applications of dynamic laser speckle[4,5] in agricultural areas.

We have made an attempt in this paper a simple, non-contact method to assess the quality parameters in grape samples by dynamic speckle phenomena. In this method, fruit image was collected using computer vision system[6,7] and assessed by fractal counting box (FBC) method.

MATERIALS AND METHODS

A high coherent laser source with the wavelength 632 nm focused on the specimen through spacial filter arrangement as shown in Figure 1. The specimen contains an average of 81% water with minerals and sugars. The interference effect happens due to the surface reflection of laser beam in various regions. The scattered laser from the skin of the specimen produces bright and dark intensity pattern due to the roughness variation of the surface. This is because the water content inside the specimen is not uniformly distributed around the seed of the specimen.

The movement of biomolecules inside the specimen makes the fluctuation in the intensity pattern. The image patterns are taken periodically. The same experiment may be done by a green laser of wavelength 541 nm (green color). The same procedure continues to take the speckle images in periodically. The similar experimental procedure is carried out for the high energy laser source (532 nm) with the power of 10 mW.

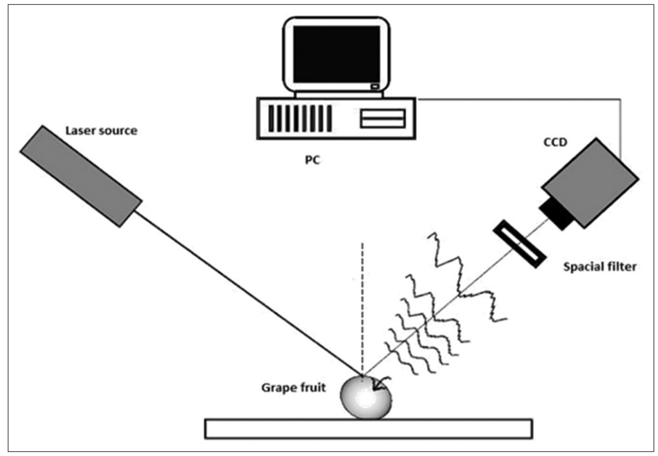

Figure 1: Schematic representation of experimental setup

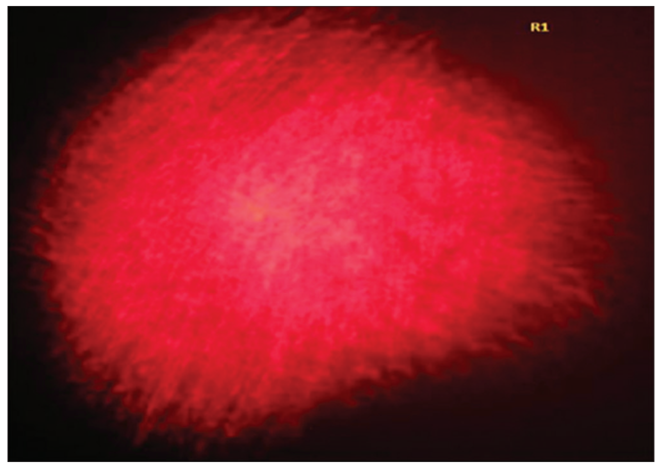

Figure 2: Speckle image R1

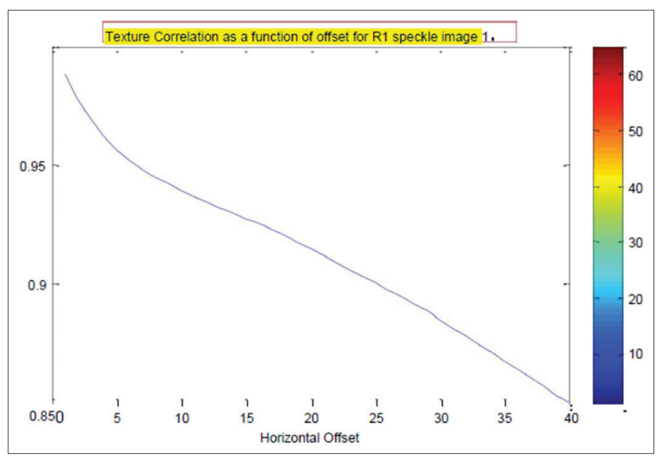

Figure 3: Speckle image R1 autocorrelation (scale in pixels)

RESULTS AND DISCUSSION

Using MATLAB software, the speckle images are converted into gray color images. The autocorrelation of speckle image (R1) is cshown in Figure 2 and its correlation is shown in Figure 3. The converted gray image (R1) modified as binary image by a suitable threshold value (here, it is 0.5). In the final stage of speckle image (R2), the specimen becomes 60% to 70% dryness as shown in Figure 4. FBC technique[8] is an efficient and accurate method in texture measuring assessment of fruit analysis.

The definition of fractal dimension is direct, and it is often difficult to estimate from the data of an image such as radiographic image. Due to these reasons, the most suitable method is appropriate to estimate fractional dimension, and hence, this is known as non-linear.

A geometric object of the specimen can be generated through the speckle images in different sizes in different regions. Such an object will be known as internal homothety or to self-similar. If we transform, a line by homothety of arbitrary ratio whose center belongs to it one finds the same line and it is same for any plane and entire Euclidean space. Hence, we can generalize non-integer dimension. The specimen S is divided in *N* objects. Similar to S in homothety, the dimension of homothety or fractal dimension in ratio is as follows:

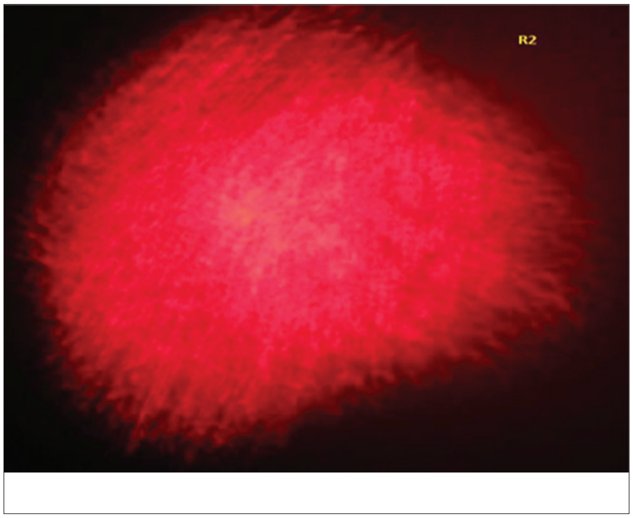

Figure 4: Speckle image R2

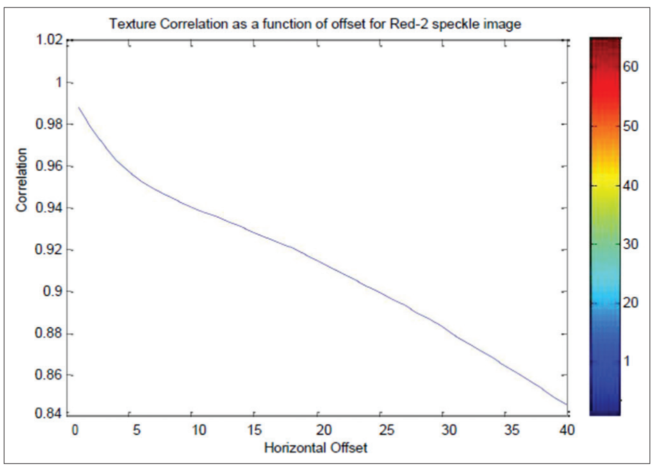

Figure 5: Speckle image R2 autocorrelation (scale in pixels)

$$D = \frac{\log N}{\log \frac{1}{r}} \quad (1)$$

However, this fractional counting method has its own limitation. It is difficult to choose the different sizes of the box for complex image, and hence, several times, the test has to be carried out. Autocorrelation of speckle image R2 is shown in Figure 5. According to the FBC theory, the speckle images (R1) give a binary counting value D = 1.7640 at initial as shown in Figure 6. The cast stage gray image converted into binary image which gives the fractal counting value D = 1.7554 as shown in Figure 7. It means that the specimen (grapes) becomes dry periodically and its value is affected by the surrounding environmental condition such as moisture and temperature.

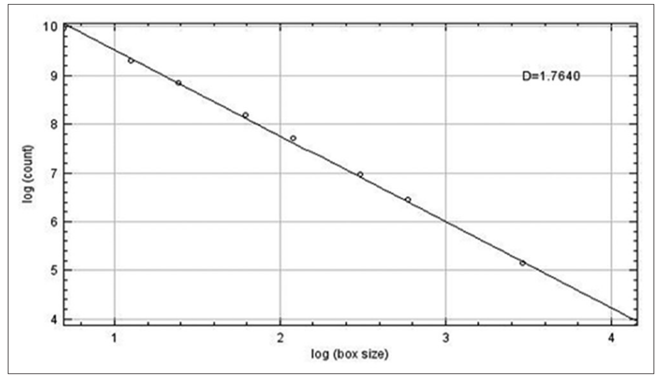

Figure 6: Fractal counting box for the R1 speckle image

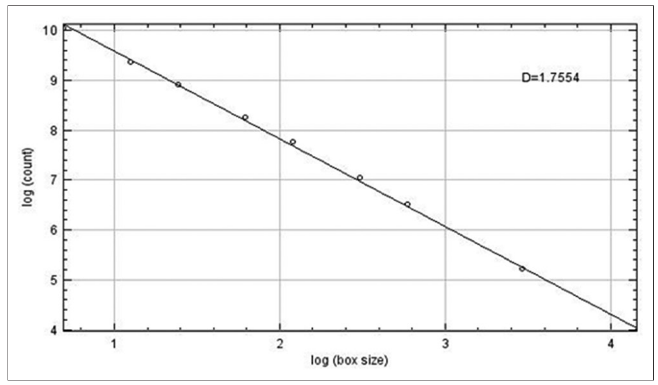

Figure 7: Fractal counting box for the R2 speckle image

CONCLUSION

We have tested grapes using the dynamic speckle phenomenon for the assessment of the shelf life activity and bruising. It was found that the visual phase of the autocorrelation function gives reliable results showing the variation in activity because of internal changes caused by decreasing water content and then becomes dry grape stage. This method is inexpensive, fast, and simple way to implement and requires only laser and digital imaging processing software. It could be a useful tool to estimate damage in various horticultural specimens.

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