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Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol 2, No.1, 2012
www.iiste.org

The translucent and yellow gummy latex of mangosteen by using the VFSS Measurement

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Abstract

The vibration frequency base on strain gage sensor (VFSS) has proposed to predict an internal translucent and yellow gummy latex in mangosteen fruit, this measurement were used nondestructive method by vibrate on 25,30,35 and 40Hz. The VFSS were obtained an evaluation of feature extraction base on time and frequency domain, which can classify by two scatter plot. From the experimental results, the first day (day1), WAMP and RMS is the best feature comparing with the other feature, there have percentage accuracy higher than the other day. From this result, this method can obtain the high classification accuracy.

Keywords: Vibration Fruit base on Strain gage Sensor (VFSS), feature extraction, yellow gummy latex and translucent.

1. Introduction

The mangosteen is the queen of fruit and one of the high economical fruit. The problem and the quality to mangosteen is measured not only by external factors such as color, shape, size, skin blemishes, latex straining and insect damage, but also by internal factors such as translucent flesh and yellow gummy latex (Sontisuk, 2007). However, many methods used determine their qualities nondestructive measurement in the fruit. In recent year, the destructive technique use to study on translucent flesh of mangosteen. Sriyont (1986) study on Neua Geaw (thai for flesh translucent) physiological disorder of mangosteen using a destructive technique. Voraphat (1996) studied the effect of water to translucent flesh disorder using chemical technique. Moreover, the non-destructive measurement of mangosteen has invented in Thailand, Pankasemsuk (1996) used to the floating technique by using differences in specific gravity is non-destructive detection of translucent fresh disorder in mangosteen. Furthermore, the microwave technique used to classify the mangosteen with a translucent fresh disorder out from the good one finding of a threshold in term of magnitude of the reflect microwave signal through a mangosteen, the monopole probe is chosen (Tawatchai, 2004). Somchai(1999) had proposed the non-destructive 2D cross-sectional visualization a mangosteen. In addition to, the near infrared spectroscopy can be accurate mangosteen (Sontisuk, 2007). The X-ray and NMR used to nondestructive internal quality evaluation of durian and mangosteen fruits (Yantarasri, 1996). The resonance frequency measurement used to detect translucent fresh disorder and yellow gummy latex (Rittisak, 2001).

From the physiological disorder of mangosteen are reliable with the water and hollow in the fruit are shown in Table 1. In recent year, the nondestructive vibration used to determine the maturity levels of durian (Kongrattanaprasert, 2001), the acoustic measurement and a intrusive method for determining tissue firmness were compared to assess the textural properties of kiwifruit (Maramatsu, 1997), firmness measurement of muskmelons by acoustic impulse transmission (Junichi, 2005), the vibration element analysis to determine firmness evaluation of melon (Nourain, 2005). Moreover, the Laser Doppler Vibrometer (LDV) technique was monitor ripening behavior temperature (Shoji, 2006), the acoustic impulses were detected internal hollow in watermelon (B. Diezma, 2002), the acoustic response evaluation of the storability of Piel de Sapo melons (L Lleó, 2005). In table 1 shown the physiological texture property of mangosteen are reliable with water and hollow. Hence, many papers presents the nondestructive firmness and differential texture property of fruit by using electrical measurement. In this paper, we propose a nondestructive technique by using VFSS measurement to detect flesh translucent and yellow gummy latex in mangosteen.

2. Material and Methods

2.1 Fruit sample and VFSS measurement

The mangosteen are purchased from a local fruit auction in Nakornsri Tummarat province, Thailand. The sample were delivered to laboratory of electrical engineering and experiment to record of signal data on the following by VFSS instrument as shown in Fig 1. About 100 sample Thai mangosteen were used to study the optimum condition of VFSS measurement and 26 intact mangosteen were used for evaluation the accuracy of translucent flesh disorder detection, 4 are translucent flesh disorder with yellow gummy latex and 20 are yellow gummy latex. The vibration signal were vibrated in medium sample at frequency was 25 to 40 Hz, amplitude input is 2.5 volt. After, the experiment was complete, the peel of each sample was slit with knife are take a photograph by digital camera, the sample were cut to record the internal as shown in Fig 2(a), 2(b),2(c)and2(d)

2.2 Instrument

The amplitude and frequency of vibration determine have many methods such as ultrasonic and accelerometer and Laser Doppler method can fix sensor with the fruit, there have response of vibration and accuracy. VFSS measurement has used in the vibration measurement of mangosteen.
The prototype system architecture for determination translucent fresh disorder and yellow gummy latex is shown in figure. The first, we put the mangosteen on the base of the prototype, base on vibration set, which can vibrate with frequency 0 – 50 Hz. The strain gauge sensor is adjusted by fix on the mangosteen. After that signals from this one sent to amplifier by instrument amplifier circuit (IC = INA 114) to A/D converter. Respectively, we can observe these signals on computer by labview programming and process them by matlab programming for classification of translucent fresh disorder and yellow gummy latex of mangosteen.

2.3. Data analysis

Feature from time domain are used in evaluation Time domain features are measured as a function of time, Because of their implementation and computation simplicity, time domain are popular in fruit analysis. All features in time domain can be implemented in real time. Nine features based on time domain are described as follows.

2.3.1 Mean Absolute Value (MAV):

MAV is similar to VFSS signal that normally used as an onset index to detect the unusual signal activity. MAV is the average of the absolute value of VFSS signal amplitude. It is defined as

$$MAV = \frac{1}{N}\sum_{i=1}^{N}\left|X_n\right| \quad (1)$$

2.3.2 Root Mean Square (RMS):

RMS is related to constant force and non-fatiguing contraction. Generally, it similar to SD, which can be expressed as

$$RMS = \sqrt{\frac{1}{N}\sum_{i=1}^{N} x_n^2} \quad (2)$$

2.3.3 Waveform length (WL):

WL is the cumulative length of waveform over time segment. WL is similar to waveform amplitude, frequency and time. The WL can be formulated as

$$WL = \sum_{n=1}^{N-1} \left| x_{n+1} - x_n \right| \quad (3)$$

2.3.4 Zero crossing (ZC):

ZC is the number of times that the amplitude values of VFSS signal crosses zero in x-axis. In VFSS feature, threshold condition is used to avoid from background noise. ZC provides an approximate estimation of frequency domain properties. The calculation is defined as

$$ZC = \sum_{n=1}^{N-1} \left[sgn\left(x_n \times x_{n+1}\right) \cap \left| x_n - x_{n+1} \right| \geq threshold \right];$$
$$sgn(x) = \begin{cases} 1, & if \quad x \geq threshold \\ 0, & otherwise. \end{cases} \quad (4)$$

2.3.5 Slope Sign Change (SSC):

SSC is related to ZC. It is another method to represent the frequency domain properties of VFSS signal calculated in time domain. The number of changes between positive and negative slope among three sequential segments are performed with threshold function for avoiding background noise in VFSS signal. It is given by

$$SSC = \sum_{n=1}^{N-1} \left[f\left[\left(x_n - x_{n-1}\right) \times \left(x_n - x_{n+1}\right) \right] \right]; \quad (5)$$
$$f(x) = \begin{cases} 1, & if \quad x \geq threshold \\ 0, & otherwise. \end{cases}$$

2.3.6 Willison amplitude (WAMP):

WAMP is the number of time resulting from the difference between VFSS signal amplitude of two adjoining segments that exceeds a predefined threshold, which is used to reduce background noises like in the calculation of ZC and SSC. It is given by

$$WAMP = \sum_{n=1}^{N-1} f\left(\left| x_n - x_{n-1} \right| \right); \quad (6)$$

$$f(x) = \begin{cases} 1, & if \quad x \geq threshold \\ 0, & otherwise. \end{cases}$$

WAMP is related to the firing of motor unit action potentials and muscle contraction level. The suitable value of threshold parameter of features in ZC, SSC, and WAMP is normally chosen between 10 and 100 mV that is dependent on the setting of gain value of instrument. However, the optimal threshold suitable for VFSS analysis is discussed later.

2.3.7 Auto-regressive (AR) coefficients:

AR model described each sample of VFSS signals as a linear combination of previous VFSS samples (x_{n-i}) plus a white noise error term (w_n). In addition, p is the order of AR model. AR coefficients (α_i) are used as features in VFSS. The definition of AR model is given by

$$x_n = -\sum_{i=1}^{p} a_i x_{n-i} + w_n \tag{7}$$

2.3.8 Mean Absolute Value Slope (MAVSLP):

MAVSLP is a modified version of MAV. The differences between the MAV of adjacent segments are determined. It can be defined as

$$MAVSLP_i = MAV_{i+1} - MAV_i; \quad i = 1,...,I-1. \tag{8}$$

where *I* is the number of segments covering VFSS signal. When the number of segments increases, it may improve the representation of the original signal over the traditional MAV.

2.3.9 Histogram (HIST):

HIST is an estimate of the probability distribution of the VFSS signal. It is given by

$$HIST = \sum_{i=1}^{j} m_i \tag{9}$$

Where m_i is the counts the number and *j* be the total number

3. Results

To demonstrate the performance of classification, In this paper, the scatter plot can be separate the property of mangosteen. From the experimental results, in the first day, the RMS and WAMP are the best feature compared to the other VFSS features as we can observe from Fig4 (a). WAMP are less than 900, the RMS are less than 0.5. However, there are some translucent and yellow gummy latex of mangosteen in their group. But also, It's some good sample are concluded in the group unusual fruit sample. In addition to, the second day (day2), the MAVSLP and SSC are the best feature compared to the other VFSS features as we can observe from Fig4 (b). MAVSLP is less than 4, the SSC are less than 240. However, it's have some translucent and yellow gummy latex of mangosteen in their group. Not only, It's some good sample are concluded in the group unusual fruit sample. The lastly, in the third day (day3) the HIST and MAVSLP are the best feature compared to the other VFSS features as we can observe from Fig4 (c). WAMP are higher than 0.008. In contrast, it's have some translucent and yellow gummy latex of mangosteen in their group. But also, some normal fruit are concluded in the group unusual fruit sample.

From the experiment results, the mangosteen from VFSS measurement on day1 of experimental is the best percentage classification is about 88.89 percentage classifier, on second day; (day 2) , there is the percent in separating mangosteen well in order later and in the third day (day3), there give the percentage classification is the poor. However, in the first day and second day can be classify the translucent and yell gummy latex in the mangosteen are respectively similar with 66.67 and 69.23 percentage correct. Moreover, percentage classifier of mangosteen, we find on second day is the best is 81.82 percentage correct. But, there are not different with on day1 and day3. From the experiment, we need day1 is the best on classification, day2 is secondary and day3 is the poor. In overall analysis image, this measurement by classifier the sample on date of experiment can detect the unusual of mangosteen is correct 78.57 percentage accuracy shown in table2.

4. Conclusion

The VFSS of mangosteen fruit was sufficient to use for flesh translucent and yellow gummy latex detection in mangosteen The results of the propose methods that the percentage classify good sample and percentage correct the good sample on the first day has the highest, the second day are the secondary, and the third day is the poor. But, the first day has percentage classify unusual sample and percentage correct unusual sample is poor. Hence, the first day is the best because there is sum correct has the highest. However, the accuracy can be increase by rejection of other effects such as hardening pericap, fruit size and skin color before evaluation.

Acknowledge

The authors acknowledge the support by the graduation scholarship, Prince of Songkla University (PSU) and would like to thank Dr. Kittinan Maliwan, lecturer in Mechanical Engineering, PSU for help technical in providing vibration set as well as Electrical Engineering(EE) Department for their Kind technical help and use of laboratory. Moreover, I would like to thank the graduation school of PSU was supported in PH.D. Scholarship.

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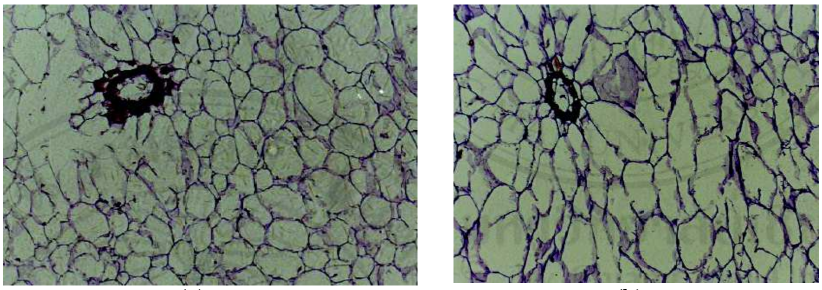
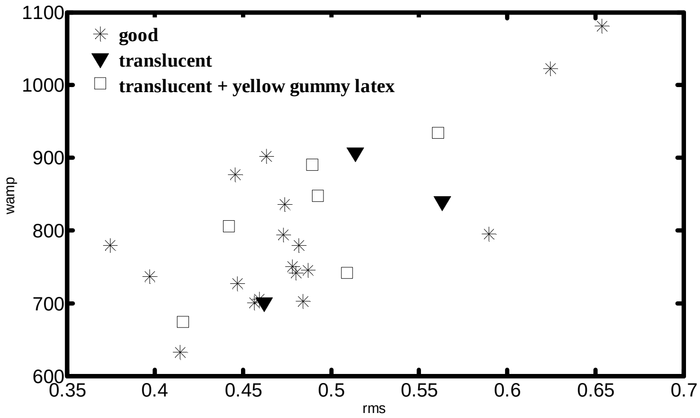


(a) (b)

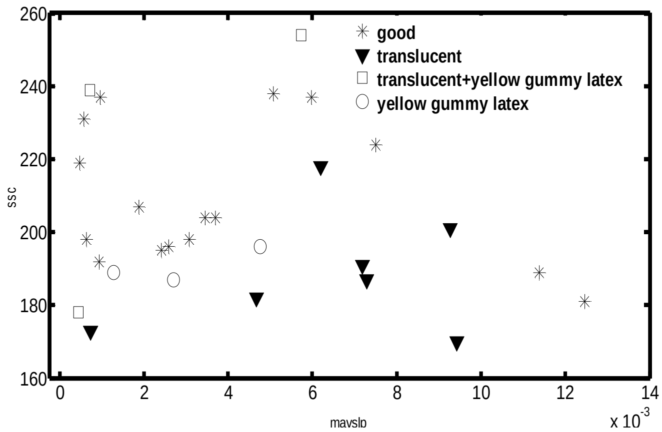
Fig 1 (a) normal of mangosteen, (b) translucent fresh disorder of mangosteen

Fig 2 (a) good sample (b) translucent sample

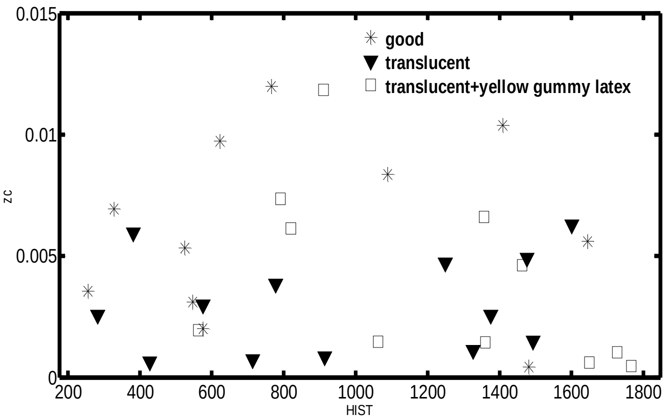
(c) translucent fruit and yellow gummy latex (d) yellow gummy latex



(a)



(b)



(c)

(a) The first day of experiment, (b) the second day of experiment. and (c) the third day of experiment.

Fig 4 the scatter plots of three texture property of mangosteen

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol 2, No.1, 2012

Table 1. The different of property in mangosteen

No.	Property	Translucent	Yellow Gummy latex	Normal	Reference
1	Opening of Cell	Solution	-	Air	(Sriyon,1986)
2	S.G.	Higher than 1	-	Lower than 1	(Vorapat,1996)
3	Water Volume		Higher than normal 1.21%		(Vorapat,1996)
4	Air Volume		Lower than normal 15		(Vorapat,1996)
5	Density		Higher than normal 3		(Vorapat,1996)

Table 2. The percentage correct of VFSS measurement

Method	Percentage correct				
	Classify good sample	Correct good sample	Classify unusual sample	Correct unusual sample	Sum correct
Group1;[Day1]	88.89	84.21	66.67	75	81.48
Group2;[Day2]	88.24	78.95	69.23	81.82	80
Group3;[Day3]	60	69.23	84.62	78.57	75.61
Total[Day1+Day2+Day3]			78.57		

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