DEVELOPMENT OF A SIMPLE INSTRUMENT TO DETERMINE WATERMELON CONSUMER ACCEPTANCE BASED ON ITS AMPLITUDE

[1]FAUZAN ROMADLON, [2]R. HANDOYO

[1]Institut Teknologi Telkom Purwokerto, Banyumas, Central Java, 53147, Indonesia
[2]Universitas GadjahMada, Daerah Istimewa Yogyakarta 55281, Indonesia
E-maiil: fauzan@ittelkom-pwt.ac.id

Abstract- Watermelon ripening level is detected by a simple method by tapping of the fruit side. Tapping aims to distinguish watermelon maturity. One theory that used to analyze the ripening is acoustics principle. Therefore, a tool to determine the level of watermelon maturity based on its amplitude is compulsory. Watermelons test that are used is 30 pieces by 10 untrained panelists and an expert. Statistical analysis shows that there are correlation between expert judgment with amplitude, 0Brix, and sensory test. Moreover, regression analysis is done to interpret amplitude from morphology aspects (weight, height, and diameter of watermelon). Other regression analysis is conducted to represent 0Brix and sensory test evaluation based on amplitude. Performing simple instrument and regression analysis will impact to logistics performance of watermelon. Farmers or traders can classify and guarantee the quality of watermelon. In consumer perspective, they will assure trader judgment because the maturity has been quantified.

Key Words- Acoustics, Amplitude, Customer Acceptance, Watermelon

I. INTRODUCTION

According to Indonesia Ministry of Agriculture, national production of watermelon is reached 653.974 ton or 3.3% from total overall fruit production in 2014 [1]. Practically, at farmers and traders level, watermelon maturity is detected by tapping sides of the fruit. They come up with this activity to classify the watermelon. However, the used method is taken time, exhausted, and has a low accuracy, especially when the process of sorting the fruit with a large capacity. Detecting watermelon maturity is determined by two methods, destructive and non-destructive. Destructive is requires to open the watermelon to see its flesh and nondestructive is intended to gain water melon ripening without opening its peel. Furthermore, Purpose of using non-destructive methods is determined from difference in the level of accuracy of the used method, materials, economic considerations, and the effects of the tested material [2]. Non-destructive method is done by several studies such as optical properties (image processing), X-ray, mechanical; vibration and sound, electromagnetics; Magnetic Resonance Imaging (MRI) and Near Infrared Spectroscopy (NIS) and chemical; electronics nose and electronics tongue [3], [4], [5], [6], [7].

Several studies have been done to detect maturity by using image sensing methods such as orange, banana, and mangosteen. Orange quality is evaluated using an image sensor camera. Orange image is recorded and analyzed using the image processing program to classify based on orange quality according to Indonesia Standards 01-3165-1992. Then, the method is compared with manual activity in orange wholesaler based on size and color [8]. Moreover, banana (*Musa cavendish*) ripening is studied by image processing at various temperatures from 50C-280C. The software is referred RGB [9] and image analysis for mangosteen is inspected density as internal quality [10].

In addition, implication of implementing Vis / NIR system is measured levels of Soluble Solid Content (SSC) or the level of sweetness of watermelon. The results show there is correlation between the values of SSC from Vis/NIR with SSC value of destructive methods [11]. NIR is also implemented for orange. The study is focused on internal and external evaluation. External evaluation is examined by the size, shape, color, and defect and the Internal is done by the sweetness, sourness, firmness, and crispness [12]. In addition, Fourier Transform Near Infrared Spectroscopy (FT-NIR) is used to identify and classify viable and non-viable watermelon seed using. The result show that there is effectiveness for observing the important wavelength region that best differentiate between viable and nonviable seeds with no required pretreatment and can potentially be automated [13].

Various researchers investigate fruit maturity using acoustics principles. Acoustics can be defined as a science to transmit and receive energy in the form of vibrations or waves in a material [14]. Tomatoes maturity is examined by developing impulse response technique to analyze the rigidity of the tomatoes during storage. The method can be used to determine the maturity level from storage until packing cause of physical changes [15]. Acoustics principle is also implemented in vibration response system. This principle is conducted to Laser Doppler Vibrometry (LDV) with providing input frequency mechanical vibrations on a watermelon and capture the resulting output frequency is then processed as a whole and

stratified by level of frequency. It is done to classify level of consumer acceptance of watermelon maturity [16]. A study determines the optimum level of maturity by estimating the relationship Elasticity Index (EI) and fruit maturity by using acoustics vibration methods [17] and applying an instrument model that named Contact Acoustic Emission Detector (CAED). The instrument is used for apple texture evaluation. The result shows that there is correlation between CAED record and overall condition of the apple [18]. Therefore, acoustics is used to detect impulse response to detect creases, bruises, and overripe of watermelon as impulse response [19], papaya quality evaluation [20], and overall fruit internal quality in Japan application [21].

Applying acoustics principle, several researchers develop instrument. The instrument is conducted to detect internal hollow of watermelon [22] and set up an instrument to predict mini watermelon based on pH that is related with color [23], android application is design to detect watermelon ripening [24]. Moreover, an acoustics instrument is developed to sort and detect the potatoes hole (*Spunta* variety) which consists of a microphone, hardware for digital signal processing, and other support equipment and the obtained accuracy is 98 % [25]. Furthermore, that non-destructive evaluation is emphasized as a critical issue for health impact and financial wellbeing of consumer. The analytical methods are capable to assess individual product units and become highly important [26]. So, this research led to use acoustics principle that is applied to detect watermelon maturity and compare with consumer acceptance by examining amplitude instead of frequency as measurement variable. It can support farmers or traders to sort and classify watermelon more quickly and accurately using simple instrument.

II. METHODS

Thirty watermelons are selected for the experiment. Those watermelons are classified by an expert. The expert is an experienced watermelon trader who is supplied from farmers and distributes watermelon to end customer. The watermelon is classified based on three categories; unripe, ripe, and overripe. Those three category is commonly used the trader to classify watermelon based on customer requirement. The chosen watermelons are kept away from contrast different morphology. Avoiding too small and to big watermelon is compulsory to get reliable and valid data. The morphological of watermelons is shown on Table I.

The maximum weight of watermelon is 5.70 Kg and 3.60 Kg for the minimum and the average is at 4.23 Kg. Minimum height of watermelon is 0.17 m and the maximum height is 0.19 m with the average of height is 0.17 m. the chosen interval height is to fit with developed instrument. The diameter is taken based on instrument fitting requirement. The maximum, minimum, and average of watermelon diameter is following 0.22 m, 0.19 m, and 0.21 m. in addition, low value of standard deviation is meant the differences of morphological of used watermelon are not conspicuous.

After determining watermelons, the simple instrument is built up (Fig. 1) with length, width, and height following 0.35m x 0.44m x 0.38m as the dimension. The Inside of simple instrument is coated by soft carpet as sound reducer to minimize some noises from tapping and outside noise. Inside the simple instrument, it is installer knocker or tapper and microphone as sensor. Microphone is plugged to computer that has been installed Cool Edit Pro software as amplitude catcher and measurer. Cool edit pro is a sound recorder free software that be able to record amplitude precisely instead of frequency. After examining all of watermelons' amplitude data, watermelon is given to ten untrained panelists. Those untrained panelists fill the questionnaire to conduct consumer acceptance survey. The classification from the questionnaire is done by three levels; dislike, normal, and like on overall watermelon flesh appearance including freshness, softness, and crunchiness. Then, taking three part of each watermelon' flesh to gain average degrees brix (^{0}Brix). Those parts are the white flesh, middle flesh and center flesh. Those fleshes are examined using ^{0}Brix meter as sugar content measurer.

TABLE I
MORPHOLOGICAL USED WATERMELON IN EXPERIMENTS

Criteria	Weight (Kg)	Height (m)	Diameter (m)
Mean	4.23	0.19	0.20
Max	5.70	0.23	0.22
Min	3.60	0.17	0.19
SD	0.61	0.14	0.009

Statistical data analysis is analyzed by Minitab 16. One-way Anova is used to interpret analyses difference between expert judgment comparing with amplitude, ^{0}Brix, and consumer acceptance. The expert judgment is used as factor analysis. Furthermore, after getting the correlation from one-way Anova, regression model is presented. Regression model is formulated to show a correlation between amplitude value and watermelon morphology; weight, height, and diameter. In addition, regression formula is set for consumer acceptance with ^{0}Brix and amplitude value.



Fig. 1 Amplitude Simple Instrument of Watermelon

III. RESULT AND DISCUSSION

A. Amplitude Instruments

Cool Edit Pro software is used to record sound from microphone by tapping watermelon. Every tapping will create wave that is recorded as shown in Fig. 2 Then, the highest or peak of the wave is taken as amplitude value of each watermelon. Higher number of the wave peak means the recorded sound is high and for lower sound determines low recorded sound. Moreover, the simple instrument uses acoustics principles design. The instrument is designed as having functions like a conventional music studio. It is set soft carpet as silencer to prevent and minimize sound reflection and getting required sound as valid as possible. The position of tapper or knocker is parallel with a microphone, and watermelon holder is between knocker and microphone. So tapper, watermelon, and microphone are set on straight-line position. By gaining desired sound level, material of knocker is made from steel plate with length x width x thickness is 12 x 1 x 0.1 cm. keeping best material will avoid defects to watermelon during data collection process.

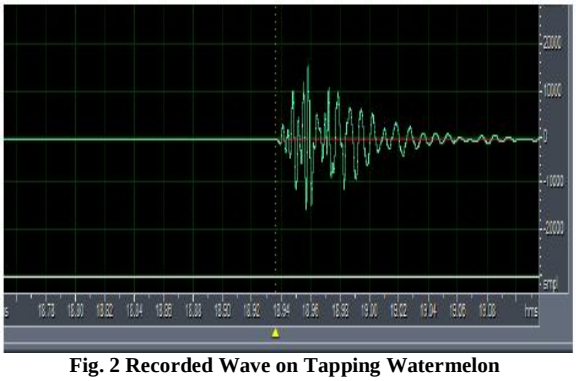


Fig. 2 Recorded Wave on Tapping Watermelon

B. Statistical Data Analysis and Regression Model

Statistical data is analysed using one-way Anova. One-way Anova is examined to analysed interaction among expert prediction versus Amplitude, expert prediction versus ^{0}Brix, and expert prediction versus sensory test. Expert classifies watermelon based on three categories; unripe, ripe, and overripe. The classification is based on flesh texture, flesh colour, and flesh appearance. The flesh texture of unripe watermelon is crunchier than ripe and overripe. The colour of flesh in unripe is red but some part is still white. In addition, the appearance of flesh of unripe watermelon is dominant white colour rather than red colour. The differences between flesh of ripe and unripe watermelon is on water level. Overripe watermelon has dominant water level than ripe watermelon. Likewise, sometimes the flesh smell is also different.

According to Table II, *p-values* of each factor are less than 0.05. It means there are any differences watermelons that are classified by the expert compare with those factors. According to expert versus amplitude analysis, different amplitude is shown with different expert classification. High amplitude represents unripe and ripe watermelon and low amplitude represents overripe of watermelon. It means that lower amplitude is classified as overripe watermelon andhigh amplitude can be determined as unripe and ripe watermelon. It seems as expert judgment that overripe watermelon has lower sound rather than ripe and unripe watermelon.

Furthermore, high value of ^{0}Brix is shown as ripe watermelon, following overripe and unripe watermelon. High values of 0Brix mean high content of sugar in watermelon. Sensory test is showed there are differences between ripe watermelon with overripe and unripe watermelon. Most of untrained consumers likes ripe watermelon rather than overripe and unripe. Overall expert prediction show different watermelon classification and can be quantified according to amplitude, 0Brix, and sensory test. The prediction is shown on Equation 1, 2, and 3.

TABLE II
ONE-WAY ANOVA RESULT

Amplitude versus expert					
Source	DF	SS	MS	F	P
Expert	2	602534000	301267000	46.02	0.00
Error	27	176769000	6547000		
Total	29	779303000			
^{0}Brix versus expert					
Source	DF	SS	MS	F	P
Expert	2	11.37	5.6	4.52	0.02
Error	27	33.97	1.26		
Total	29	45.34			
Sensory test versus expert					
Source	DF	SS	MS	F	P
Expert	2	3.469	1.734	13.13	0.00
Error	27	3.566	0.132		
Total	29	7.035			

Equation (1) is done by regression analysis that represents prediction of amplitude based on known weight, height, and diameter watermelon. It indicates that amplitude of watermelon is caused of the morphology aspect. The morphology of watermelon is used to do sorting and classifying. So, Low or high amplitude can be quantified precisely and minimized human error.

$$\text{Amplitude} = 173957 + 13875\ \text{Weight} - 3096\ \text{Height} - 7397\ \text{Diameter} \quad (1)$$

$$^{0}\text{Brix} = 7.72 + 0.000025\ \text{Amplitude} \quad (2)$$

$$\text{Sensory Test} = 0.996 + 0.000045\ \text{Amplitude} \quad (3)$$

Gaining amplitude as acoustics preference can be a factor to evaluate ^{0}Brix and sensory test referring (2) and (3). It gives more benefit for logistics performances. Farmers or traders can do further to classify watermelon based on those criteria. The criteria can be used on during delivery and selling into customer. For delivery process, farmers or traders can estimate delivery time to customer and suitable watermelon should be picked up. The suitable watermelon that delivered into customer can minimize watermelon loss and increasing the profit. Furthermore, by using the simple instrument and applying the equation, both end customer and seller can be convinced each other. Selling process will be faster without destructing watermelon. So, untrained seller or customer can justify and pick which watermelon is suitable to consume.

CONCLUSION

This study investigates developing simple instrument to measure consumer acceptance based on ^{0}Brix and sensory test. The simple instrument is designed based on acoustics methods and used amplitude as measurement criteria. Amplitude is used to determine watermelon expert judgment; unripe, ripe, and overripe. Statistical analysis is done to test the correlation between expert judgment with amplitude, ^{0}Brix and sensory test. The results show that there is correlation between expert judgment those variable. Furthermore, conducting regression analysis is done to estimate the value of amplitude based on watermelon morphology. Amplitude is used as a factor to estimate ^{0}Brix and sensory test of watermelon without destructing. Amplitude value can be considered factor for farmer and wholesaler before distributing watermelon into customer. Distributing good quality of watermelon will increase their profit and minimize their loss. Further study can be done to conduct an application based on amplitude referring regression analysis equations.

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