NON-DESTRUCTIVE QUALITY EVALUATION OF DRAGON FRUIT USING ULTRASOUND METHOD

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ABSTRACT

In Indonesia, the quality of dragon fruit is still commonly determined manually by using visual appearances. This method is objected to inconsistency measurement caused by human errors that will result un-uniformity quality qualification and also it is unable to measure internal quality of the fruits. Destructive method is commonly used to determine internal quality of dragon fruit, but it is un-applicable for controlling the quality of fresh dragon fruit. So, non destructive method is required for evaluation the quality of dragon fruit.

The objectives of the research were to determine the physicochemical and ultrasound wave transmission characteristics of super red dragon fruit in three maturities and to study the relationship between ultrasound wave transmission characteristics and physicochemical characteristics of super red dragon fruit. Super-red dragon fruits were harvested at 30, 32, and 34 days after flower blooms (AFB). The results showed that the ultrasound velocity of super red dragon fruit ranged from 614,10 to 680,58 meter per second and the attenuation coefficient was 57,71 to 62,22 Neper per meter. The attenuation coefficient was significantly different in three maturities. There were significant correlations between ultrasound parameters, (i.e. velocity and attenuation coefficient) and physicochemical (i.e. firmness, sugar content, total soluble solid, and total acid) of super red dragon fruit.

Keywords: Attenuation, Dragon fruit, Ultrasound, Velocity

INTRODUCTION

Dragon fruit is newly introduced to the consumers in Indonesia, however some provinces in Indonesia have developed the cultivation of this product. It is a promising product in domestic market. The cultivation of dragon fruit gives many benefits, not only for the cultivators but also for reducing import rate and if possible penetrating export market. In 2006, the total production of local estates in Malang, Yogyakarta, Semarang, Pasuruan, Jombang, and Klaten reached 1,341 tons/year. Fruit production is increasing every year due to increasing demand.

Post harvest handling in domestic market includes sorting, grading, packaging, and transporting. Sorting and grading are done manually through fruit visual appearance which causes un-uniformity results. Internal quality of fruit such as sweetness must be determined using destructive method known as sampling. Since it's destructively characteristic that is not appropriate for handling fresh fruit, a non-destructive is importantly needed to be applied.

One of successful non-destructive methods in determining fruit quality is ultrasound wave (Budiastra, *et al*, 1999). Ultrasound has shown satisfying results in determining quality of mango (Mizrach *et al*, 1997), avocado (Gallili *et al*, 1993), cherry-tomato (Trisnobudi, 1998), mangosteen (Juansyah, 2005), and durian (Haryanto, 2002). Ultrasound method has not yet been experimented for dragon fruit quality evaluation.

The objective of the study was to develop non-destructive quality evaluation of super red dragon fruit using ultrasound wave method, specific objectives were: a)determining ultrasound wave transmission characteristics of three levels maturity, b) determining physicochemical characteristics of three levels maturity, c) determining the relationship between ultrasound wave transmission characteristics and physicochemical characteristics.

MATERIALS AND METHODS

Plant materials

Dragon fruit (*Hylocereus costaricensis*) used in this research was super red dragon fruit and produced from the dragon fruit farm of PT. Wahana Cory, Ciapus, Bogor, West Java. The fruits were grade B with red color for either the skin and the flesh. The average diameter and weight are 8 cm and 250 – 350 gram, respectively . The fruits were picked in three levels maturitiy, i.e. 30, 32, and 34 after flower blooms (AFB). Fifty samples were collected in each sample.

Ultrasound wave experiment materials

Material used in this study was ultrasound wave measurement system shown in Figure 1 (Budiastra *et al*, 1999). It consisted of transmitter and receiver transducer, transducer seat was equipped with sample thickness gauge, digital oscilloscope ETC M621, ultrasound transmitter, and personal computer. Transducer was cylinder with cone tip, with 2,95 cm diameter, 7,5 cm long, and transmitted frequency was approximately at 50 kHz. Other measuring tools were Color Reader Minolta CR-10 (color), Rheometer model CR 300 DX-L (firmness), digital scale (mass), vernier caliper (measure), and portable digital refractometer (total soluble solid).

Experimental procedures

Ultrasound wave characteristic measurement was carried out in each level maturity. The parameters were velocity and ultrasound wave transmission.

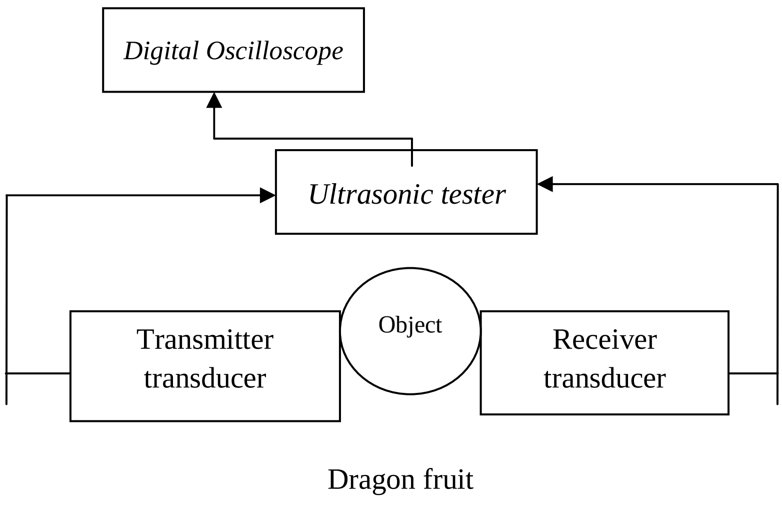


Figure 1. Block diagram of ultrasonic wave measurement

After measuring ultrasound wave characteristic, next procedure was measuring physicochemical characteristics of the fruit. The parameters were firmness, color, density, total sugar (*Luff Schrooll*), total acid (titration), and total soluble solid. The last procedure was evaluating quality measurements such as texture, color, and taste through sensoric method, with seven levels of consumer preference. Total panelists were 25 people.

Data processing and analyzing

Velocity was determined by fruit diameter ratio to transfer time of wave inside flesh. Ultrasound wave transmission shown the relationship between amplitude (voltage) and time was transformed using FFT (Fast Fourier Transform) with Matlab software into Power Spectral Density (PSD). Attenuation coefficient was measured from zero moment power. Zero moment power was the area below PSD. Ultrasound data and physicochemical characteristics were then analyzed with Analysis of Variance (ANOVA), Honestly Significant Difference (HSD) at 5% and correlation analysis with Minitab Release 14.

RESULTS AND DISCUSSION

Ultrasound wave transmission characteristic at three levels maturity

Ultrasound wave velocity and attenuation coefficient at three levels maturity were significantly different, whereas zero moment power was not. When the fruit maturity increased, the velocity of ultrasound wave tends to decrease and attenuation coefficient increased (Table 1).

Ultrasound wave velocity in fruit was affected by fruit firmness and density. Trisnobudi (2006) explained, theoretically, ultrasound velocity was affected by physical characteristics such as Young modulus (firmness) and mass density; however in this experiment Young modulus was more dominant than density. If the maturity is higher, the fruits tend to be softer. It was caused by the diminishing of protopectin which was not soluble in water and increasing of soluble pectin causing solid structure of cell wall diminished. Therefore, ultrasound wave velocity was more difficult to transfer inside the flesh and resulted to slower velocity. Ultrasound wave was easier to penetrate solid medium than liquid or gas (Gooberman, 1968).

Table 1. The average value of super red dragon fruit ultrasound wave transmission according to maturity

Acoustic Property	30 AFB	32 AFB	34 AFB
Velocity (m/second)	680,58 ± 10,49 c	671,62 ± 10,12 b	614,10 ± 9,87 a
Attenuation (Np/m)	57,71 ± 0,74 a	59,50 ± 0,76 b	62,22 ± 0,90 c
Zero moment power	3,5711 ± 0,0626 a	3,5524 ± 0,0943 a	3,5227 ± 0,2540 a

Notes: average followed by the same letters in columns does not differ between them by Duncan Test (p<0.05)

The physicochemical characteristic at three levels of maturity

Firmness, color b-y (blue-yellow), and chemical properties (total sugar and total acid) of super red dragon fruit were significantly different at each maturity, other physic0chemical properties were variously different at each maturity. It was caused by wide range of variation of physicochemical data at every maturity (Table 2).

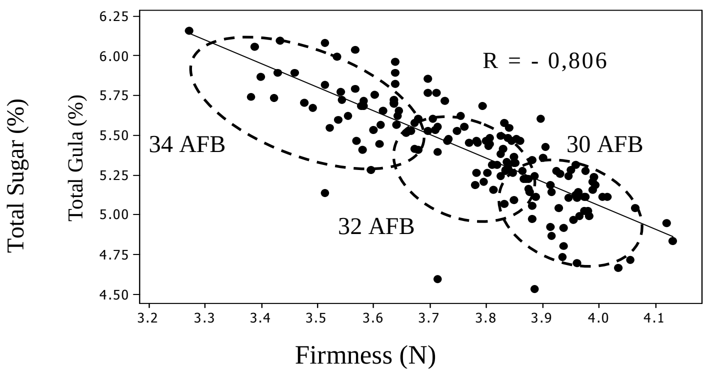
Table 2. The Average Value of Dragon Fruit Physico-chemical Properties According to maturity

Physicochemical Properties	30 AFB	32 AFB	34 AFB
Firmness (N)	3,865 ± 0,059 c	3,793±0,088 b	3,658±0,048 a
Density (gr/cm$^{3)}$	0,98 ± 0,02 ab	0,97 ± 0,04 a	0,99 ± 0,01 b
Color Degree:			
Chroma	20,00 ± 2,83 a	23,87 ± 2,07 b	24,19 ± 2,30 b
L	43,23 ± 1,36 b	42,34 ± 2,80 a	42,69 ± 0,84 a
a	17,07 ± 3,27 a	22,27 ± 2,36 b	22,91 ± 2,53 b
b	10,09 ± 1,33 c	8,35 ± 0,80 b	7,51 ± 1,29 a
Total Sugar (%)	4,39 ± 0,26 a	5,31 ± 0,30 b	6,03 ± 0,32 c
Total Acid (%)	2,83 ± 0,12 c	2,19 ± 0,23 b	1,47 ± 0,08 a
TPT (^{o}Brix)	10,22±1,17 a	11,84±1,52 b	11,75±1,07 b

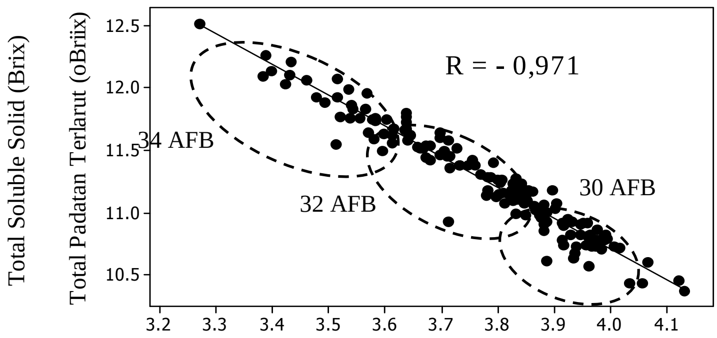
Notes: Average followed by the same letters in columns does not differ between them by Duncan Test (p<0.05)

Firmness and total acid content of super red dragon fruit decreased as the harvest time increased, whereas total sugar content and total soluble solid increased. It was caused by the change of starch into monosaccharide. Total acid decreased because organic acid used by fruit cell as a component in metabolism activity (Pantastico, 1990).

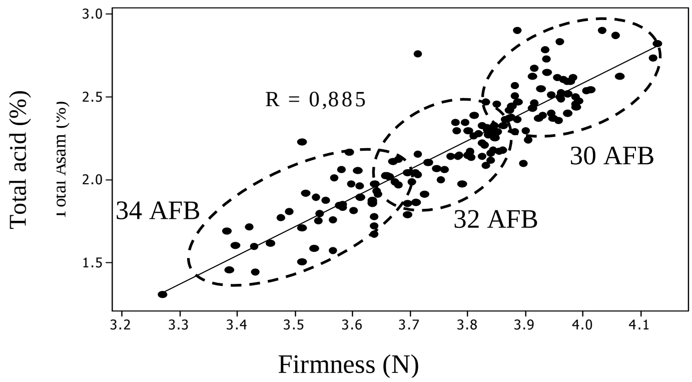
The correlation between physical properties (i.e. firmness) and chemical properties i.e. total sugar, total acid, and total soluble solid) were significant (Figure 2). Firmness and total sugar and also total soluble solid had negative correlation (Figure 2a and 2b) while firmness and total acid had positive correlation (Figure 2c). The firmness decreased and caused total sugar content and total soluble solid (TSS) increased. On the contrary, total acid decreased.



(a)



(b)



(c)

Figure 2. The Correlation between Physical Properties and Chemical Properties

(a) Firmness and total sugar

(b) Firmness and TSS

(c) Firmness and total acid

The relationship between ultrasound wave transmission and physicochemical characteristic

Ultrasound wave velocity and firmness had positive correlation. The firmness decreased and directly resulted to the decreasing of ultrasound wave velocity (Figure 3a). Ultrasound wave velocity and total sugar was negatively correlated (Figure 3b), on the contrary, ultrasound wave velocity and total acid was positively correlated (Figure 3c). Ultrasound wave velocity decreased as total sugar increased and total acid decreased.

Attenuation coefficient, firmness, and total acid of dragon fruit were negatively correlated (Figure 4a and 4c). On the contrary, attenuation coefficient and total sugar were positively correlated (Figure 4b). Attenuation coefficient increased as total acid decreased and total sugar increased. Dragon fruit with the youngest maturity has compact cell structure, as the fruit gets more mature the cells are filled with sugar and water, expanding the shape. It is assumed that more water content in the cells and decreasing of dragon fruit acid content affected to increase of attenuation coefficient. Attenuation is a decreasing in total energy intensity or the wave after passing through the medium. According to Trisnobudi (2006), attenuation is caused by medium absorption because of energy conversion (acoustic energy to other kind of energy). Attenuation is also caused by reflection and refraction of structure in medium.

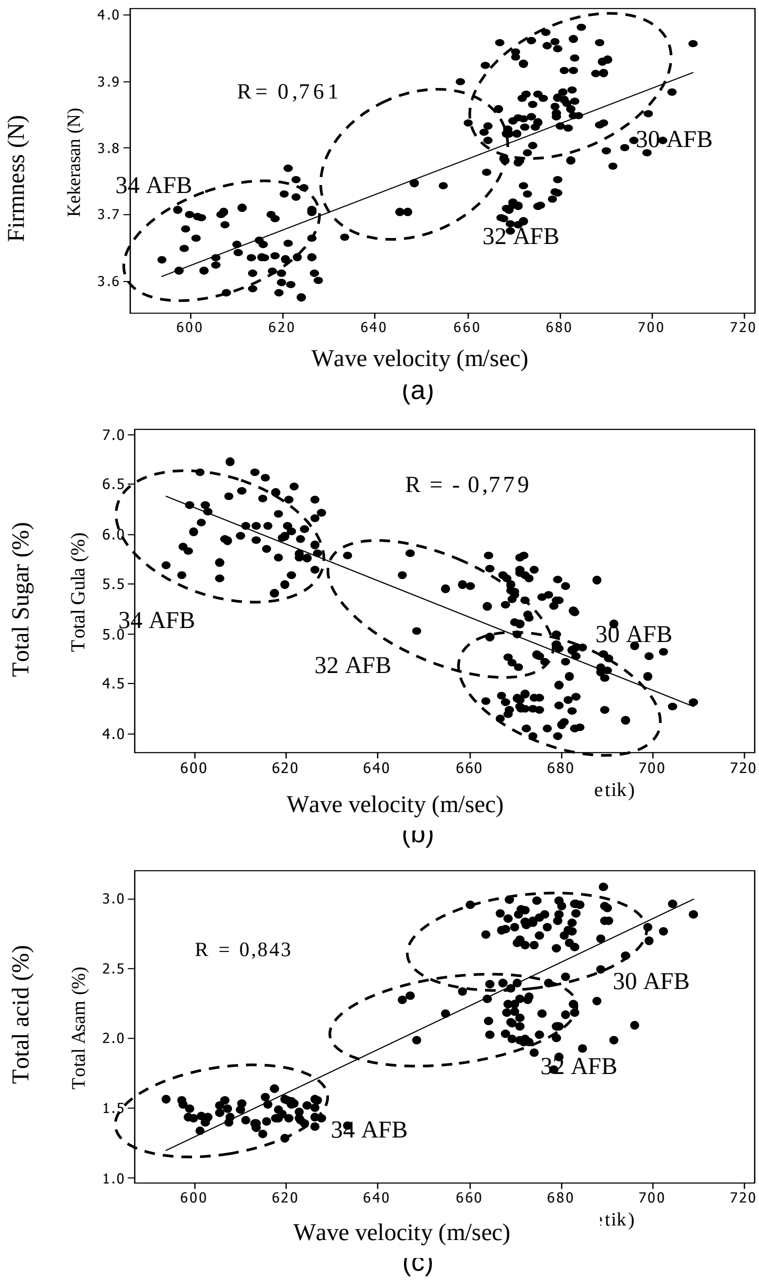


Figure 3. The Correlation between Ultrasound Velocity and Firmness, Total Sugar and Total Acid

(a) Graph of velocity to firmness
(b) Graph of velocity to total sugar
(c) Graph of velocity to total acid

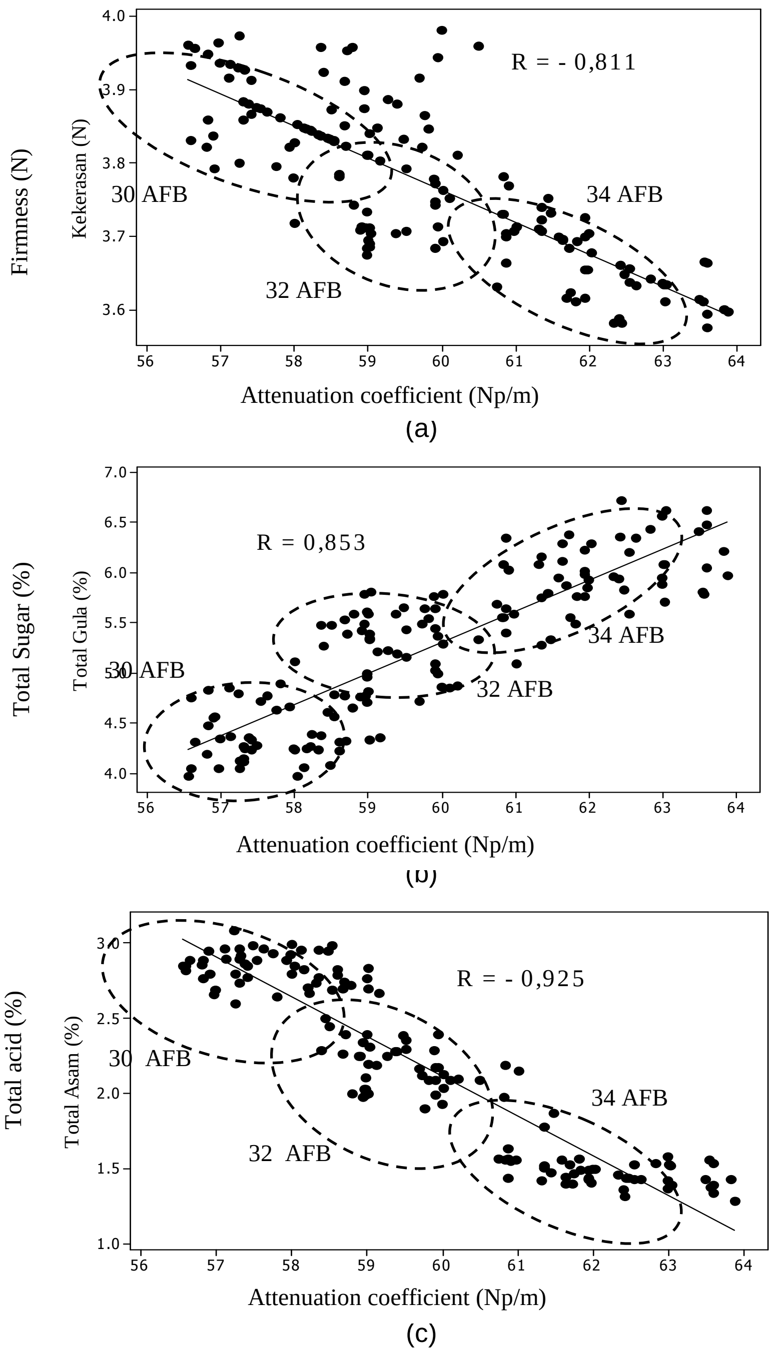


Figure 4. The Correlation between Attenuation Coefficients and Firmness

(a) Graph of attenuation coefficient to firmness
(b) Graph of attenuation coefficient to total sugar
(c) Graph of attenuation coefficient to total acid

Model validation of physical and mechanical properties according to ultrasound characteristic

Ultrasound characteristic model relation (attenuation coefficient and velocity) with physical properties (firmness) and chemical properties (total sugar, total acid, and total soluble solid) as shown in Figure 3 and 4, need to be tested with a validation test to find out how close the correlation between those parameters. Using the equation from the experiment to assume physical and chemical properties then compared to the result. The comparison between prediction result and observation result was as accuracy relative value (Kr). Validation test was conducted to 150 samples. The average prediction and observation of firmness, total sugar, total acid and also total soluble solid according to ultrasound characteristic shown in Table 3.

Table 3. Dragon fruit physicochemical properties validation test according to ultrasound characteristics

Physicochemical properties	Ultrasound velocity			Attenuation coefficient		
	Observation	Prediction	Kr (%)	Observation	Prediction	Kr (%)
Firmness (N)	3.7711	3.7697	99,86	3.7711	3.7709	99,89
Total Sugar (%)	5.2497	5.2626	95,52	5.2497	5.2545	97,16
Total Acid (%)	2.1626	2.1565	95,21	2.1626	2.1650	97,65

CONCLUSIONS

1. Velocity and ultrasound wave attenuation coefficient at three levels of maturity were significantly different. Otherwise, zero moment power was not significantly different.
2. The higher the fruits' maturity, the lower velocity will be achieved. The attenuation coefficient itself increased.
3. Firmness and chemical properties (i.e. total sugar, total acid, and total soluble solid) of dragon fruit were significantly correlated. In response of firmness to total sugar was negatively correlated; firmness to total acid was positively correlated, while firmness to total soluble solid was negatively correlated.
4. Ultrasound velocity and physicochemical characteristic was significantly correlated. Ultrasound velocity to firmness and total acid as well were positively correlated, while with total acid was negatively correlated.
5. Ultrasound attenuation coefficient and physicochemical was significantly correlated. Attenuation coefficient to firmness was negatively correlated, also with total acid. While attenuation coefficient and total sugar were positively correlated.

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