

Ultrasonic Technique for Predicting Grittiness of Salted Duck Egg

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Abstract. Grittiness of egg yolk is a major factor in consumer acceptance of salted duck egg product. Commonly, the grittiness level is determined by the destructive method. Salted egg industries need a grading system that can judge the grittiness accurately and nondestructively. The purpose of this study was to develop a method for determining grittiness of salted duck eggs nondestructively based on ultrasonic method. This study used 100 samples of salted duck eggs with 7,10,14 and 21 days of salting age. Velocity and attenuation were measured by an ultrasonic system at frequency 50 kHz, followed by physicochemical properties measurement (hardness of egg yolks and salt content), and organoleptic test. Ultrasonic wave velocity in salted duck eggs ranged from 620.6 m/s to 1334.6 m/s, while the coefficient of attenuation value ranged from – 0.76 dB/m to -0.51 dB/m. Yolk hardness was 2.68 N at 7 days to 5.54 N at 21 days of salting age. Salt content was 1.81 % at 7 days to 5.71 % at 21 days of salting age. Highest scores of organoleptic tests on salted duck eggs were 4.23 and 4.18 for 10 and 14 days of salting age, respectively. Discriminant function using ultrasonic velocity variables in minor and major diameter could predict grittiness with 95 % accuracy.

1. Introduction

Production of salted duck eggs from 2011 to 2015 increased from 256.2 thousand tons to 282.6 thousand tons [1]. Duck eggs contributed 15.56 % of the national egg production in 2015. Duck eggs are generally preserved and processed into salted eggs and very popular in Indonesia and Asia. Chi and Tseng [2] reported that generally salted eggs are made from duck eggs because of protein and fat content in egg yolks 19.08 % and 36.53 % respectively higher than chicken eggs 16.32 % and 32.25 %.

Conventionally, egg is coated with a red soil paste mixed with salt, or it is immersed in the salt solution. During salting, the yolk gradually becomes solidified and hardened and could form a gritty texture [2], [3]. The grittiness quality of salted duck egg is obtained from the yolk. The grittiness is a major factor affecting consumer acceptance of salted egg product [2]. The grittiness level of the salted duck egg is determined by destructive method. The salted duck egg industries need a grading system that can judge the grittiness accurately and nondestructively.

The purpose of this study was to develop a method for determining grittiness of salted duck egg nondestructively based on ultrasonic method. More specific purpose of this study are: a) to determine characteristics of ultrasonic wave transmissions and physicochemical characteristics of salted duck egg at four of salting age, b) to determine the relationships between ultrasonic properties and the physicochemical properties of salted duck eggs, and c) to predict grittiness of salted duck egg based on ultrasonic properties.



2. Materials and methods

Salted duck egg used in this study was obtained from Sidoarjo district, East Java, Indonesia. One hundred samples of cooked salted egg consisted of 7,10,14 and 21 days of salting age were measured by an ultrasonic system at frequency 50 kHz [4], this frequency was recommended as an appropriate one for characterization of agricultural materials [5], followed by physicochemical properties measurement (hardness of egg yolks and salt content), and organoleptic test. Ultrasonic properties (velocity and attenuation) in minor and major diameter were measured (figure.1) and calculated using ultrasonic equations [6].

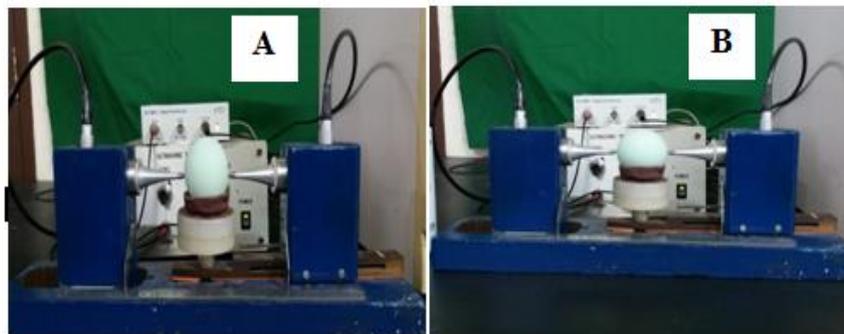


Figure 1. Ultrasonic measurement at minor diameter (A) and major diameter (B) of salted egg

Yolk hardness was measured using CR 300 DX-L Model Rheometer, with experimental set up as follows; mode of 20, maximum load of 20 mm/minutes and probe diameter of 5 mm. Salt content was determined by rapid analysis of modified Mohr method [7]. An organoleptic test was conducted with 22 trained panelists. The organoleptic test parameters were general appearance, salting taste of egg white and gritty texture of egg yolk with the scoring scale consists of: (1) very dislike; (2) dislike; (3) neutral; (4) like; (5) very like [8]. Relationships between ultrasonic and physicochemical properties were analyzed using linear regression. Discriminant function of ultrasonic properties of the salted egg was developed to classify the grittiness of salted duck egg.

3. Results and discussion

3.1. Ultrasonic and Physicochemical Characteristics of Salted Duck Egg

Ultrasonic properties of salted duck egg are shown in table 1. The velocity of ultrasound passing through the salted duck egg increased from 7 days to 21 days of salting age. Attenuation coefficient did not change significantly. Physicochemical properties of the salted duck egg are showed in table 2. The hardness of egg yolk was 2.68 N at 7 days to 5.54 N at 21 days of salting age. Salt content was 1.81 % at 7 days to 5.71 % at 21 days of salting age.

Table 1. Ultrasonic properties of salted duck egg at four of salting age

Ultrasonic Properties	7 Day	10 Day	14 Day	21 Day
Velocity in minor diameter (m/s)	720.30 ^d	863.42 ^c	995.40 ^b	1334.60 ^a
Velocity in major diameter (m/s)	620.60 ^d	730.90 ^c	914.80 ^b	1057.30 ^a
Attenuation in minor diameter (dB/m)	-0.71 ^a	-0.75 ^a	-0.76 ^a	-0.71 ^a
Attenuation in major diameter (dB/m)	-0.51 ^a	-0.65 ^c	-0.59 ^b	-0.63 ^{bc}

Notes: Different superscripts in the same row indicate significant differences ($p < 0.05$)

Table 2. Physicochemical properties of salted duck egg at four of salting age

Physicochemical Properties	7 Day	10 Day	14 Day	21 Day
Hardness of egg yolk (N)	2.68 ^c	3.05 ^{bc}	3.46 ^b	5.54 ^a
Hardness of egg white (N)	3.98 ^a	3.87 ^a	3.08 ^b	0.29 ^c
Hardness of egg shell (N)	38.46 ^a	39.28 ^a	40.02 ^a	39.67 ^a
Salt content (%)	1.81 ^b	3.31 ^{ab}	4.97 ^{ab}	5.71 ^a
Moisture content (%)	66.94 ^a	67.17 ^a	65.22 ^a	59.10 ^a
Lipid (%)	12.98 ^a	12.97 ^a	13.83 ^a	17.49 ^a
Protein (%)	13.02 ^a	12.76 ^a	10.90 ^a	10.91 ^a

Notes: Different superscripts in the same row indicate significant differences ($p < 0.05$)

3.2. Organoleptic test result of salted duck egg

The organoleptic test result of salted duck egg at four of salting age is shown in table 3. Highest scores of grittiness level of organoleptic tests on salted duck eggs were 4.23 and 4.18 for 10 and 14 days of salting age, respectively. Since the organoleptic score of 10 and 14 days is not significantly different, these salting age will be classified into one group. Beside grittiness level, the level of consumer preference in salted duck eggs depends on the salty taste of egg whites and appearance of an interesting orange color of egg yolk (table 3).

3.3. Relationship between ultrasonic and physicochemical characteristic

The relationship between ultrasonic and physicochemical properties is shown in table 4. The velocity of ultrasound passing through the salted duck egg had significant linear correlations with physicochemical properties of salted duck egg. But, the attenuation coefficient had no significant linear correlation with physicochemical properties of salted duck egg. During salting, the egg yolk gradually becomes solidified and hardened [1]. Kaewanee *et al.* [3] reported that the microstructure of salted egg yolk by SEM (Scanning Electron Micrograph) indicated that polyhedral granules were more closely localized than those in fresh egg yolk. Ultrasonic wave more easily passes through a solid medium than non-solid medium [9]. Changes of physical properties in egg material (changes in hardness of egg yolk) have a direct impact on the velocity of ultrasound propagating through the egg material.

Table 3. Organoleptic test result of salted duck egg

Scoring Scale	7 Day	10 Day	14 Day	21 Day
General appearance	3.14 ^b	4.18 ^a	3.82 ^{ab}	2.32 ^c
Salty taste of egg whites	3.18 ^b	4.09 ^a	3.55 ^{ab}	1.50 ^c
Gritty texture of egg yolk	2.05 ^c	4.23 ^a	4.18 ^a	3.14 ^b

Notes: Different superscripts in the same row indicate significant differences ($p < 0.05$)

Table 4. Relationship (r) between ultrasonic and physicochemical characteristic of salted egg

Variables	Hardness of egg yolk	Salt Content
	(n=100)	(n=12)
Velocity in minor diameter	0.7756	0.8171
Velocity in major diameter	0.6021	0.8868
Attenuation in minor diameter	0.0360	0.0162
Attenuation in major diameter	-0.2920	-0.3266

Notes: n = number of data analyzed

3.4. Grittiness prediction of salted duck egg based on ultrasonic characteristic

The various discriminant functions of ultrasonic properties were established to classify grittiness of salted egg into 3 groups, that is D_3 (not gritty) D_4 (gritty) and D_5 (very gritty) (table 5). The best of classification of the grittiness of salted duck egg was obtained using the discriminant function of velocity variables in minor and major diameter with an accuracy of 95 %.

Table 5. Classification results of salted duck egg using discriminant function of ultrasonic variables

Variables	Formed Function (D_i), n=80	Validation (n=20)
Velocity in minor diameter (X_1) and attenuation in minor diameter (Y_1)	$D_3 = -177.6761 + 0.2068X_1 - 281.8322Y_1 - 0.0001X_1^2 + 0.0330X_1Y_1 - 181.4139Y_1^2$ $D_4 = -42.9160 + 0.0451X_1 - 25.2319Y_1 + X_1^2 - 0.043X_1Y_1 - 21.5219Y_1^2$ $D_5 = -144.7076 + 0.1287X_1 - 221.0496Y_1 - 0.0001X_1^2 - 0.0294X_1Y_1 - 165.5990Y_1^2$	90 %
Velocity in minor diameter (X_1) and velocity in major diameter (X_2)	$D_3 = -79.3011 + 0.2188X_1 - 0.0318X_2 - 0.0002X_1^2 + 0.0002X_1X_2 - 0.0001X_2^2$ $D_4 = -58.7536 + 0.0417X_1 + 0.0383X_2 + X_1^2 + X_1X_2 + X_2^2$ $D_5 = -79.5193 + 0.1412X_1 + 0.0102X_2 - 0.0001X_1^2 + X_1X_2 + X_2^2$	95 %
Velocity in major diameter (X_2) and attenuation in major diameter (Y_2)	$D_3 = -26.1298 + 0.0379X_2 - 40.5928Y_2 + X_2^2 - 0.0293X_2Y_2 - 56.8370Y_2^2$ $D_4 = -263.4847 + 0.0856X_2 - 6757862Y_2 + X_2^2 + 0.0566X_2Y_2 - 483.2326Y_2^2$ $D_5 = -124.0024 + 0.0808X_2 - 283.0569Y_2 + X_2^2 + 0.0519X_2Y_2 - 192.7464Y_2^2$	70%
Velocity and attenuation in minor diameter (X_1, Y_1) and velocity and attenuation in major diameter (X_2, Y_2)	$D_3 = -202.3230 + 0.2957X_1 - 0.0785X_2 - 289.3941Y_1 - 47.3170Y_2 - 0.0002X_1^2 + 0.0002X_1X_2 + 0.0701X_1Y_1 + 0.0388X_1Y_2 - 0.0001X_2^2 - 0.0287X_2Y_1 - 0.0444X_2Y_2 - 187.8915Y_1^2 + 20.5335Y_1Y_2 - 59.3858Y_2^2$ $D_4 = -366.0625 + 0.0826X_1 + 0.0959X_2 + 57.2340Y_1 - 867.1685Y_2 + X_1^2 + X_1X_2 + 0.0079X_1Y_1 + 0.0588X_1Y_2 + X_2^2 - 0.0183X_2Y_1 + 0.0865X_2Y_2 - 27.2632Y_1^2 + 104.6285Y_1Y_2 - 607.5533Y_2^2$ $D_5 = -391.2293 + 0.3568X_1 + 0.0251X_2 - 108.6289Y_1 - 548.1938Y_2 - 0.0001X_1^2 + X_1X_2 - 0.0642X_1Y_1 + 0.2501X_1Y_2 + X_2^2 - 0.0346X_2Y_1 + 0.0364X_2Y_2 - 84.8597Y_1^2 + 129.5048Y_1Y_2 - 307.2995Y_2^2$	90 %

Notes: D_i =Discriminant scoring of salted duck eggs (where: $i=3$; not gritty, $i=4$; gritty and $i=5$; very gritty) and n was number of data analyzed

4. Conclusions

Ultrasonic wave velocity in salted duck eggs ranged from 620.6 m/s to 1334.6 m/s, while the coefficient of attenuation value ranged from -0.76 dB/m to -0.51 dB/m. Yolk hardness was 2.68 N at 7 days to 5.54 N at 21 days of salting age. Salt content was 1.81 % at 7 days to 5.71 % at 21 days of salting age. Highest scores of organoleptic tests on salted duck eggs were 4.23 and 4.18 for 10 and 14 days of salting age, respectively. The velocity of ultrasound passing through the salted duck egg had a significant correlation with yolk hardness and salt content, while attenuation coefficient had no significant correlation with physicochemical characteristics. Discriminant function using velocity variables in minor and major diameter could predict grittiness with 95 % accuracy.

5. References

- [1] Director General of Livestock and Animal Health Services 2015 *Statistic of livestock and Animal* (in Indonesian). Available at: [http:// ditjennak.pertanian.go.id](http://ditjenhik.pertanian.go.id).
- [2] Chi S P and Tseng K H 1998 Physicochemical properties of salted pickled yolk from duck and chicken eggs *Journal Food Science* **63**(1): 27–30.
- [3] Kaewmanee T, Benjakul S and Visessanguan W 2009 Changes in chemical composition, physical properties and microstructure of duck egg as influenced by salting *Food Chemistry* **112**(3): 560–569
- [4] Juansah J, Budiastira I W and Suroso 2005 Development of ultrasonic measurement system for manggis (*Gracinia Mangostana* L) (in Indonesian) *Jurnal Keteknik Pertanian* **20**(2):167-178
- [5] Mizrach A, Galili N and Rosenhouse G 1989 Determination of fruit and vegetable properties by ultrasonic excitation *Trans. ASAE* **32**: 2053–58.
- [6] Krautkramer J, Krautkramer H 1990 *Ultrasonic testing of materials* (Heidelberg: Springer-Verlag)
- [7] Faridah N, Kusnandar F, Herawati D, Kusmaningrum HD, Wulandari N and Indrasti D 2010 Laboratory Guide for Food Analysis (in Indonesian). (Bogor: Graduate School of Bogor Agricultural University)
- [8] Setyaningsi D, Apriantono A and Puspitasari M 2010 *Sensoris analysis for food and agro industry* (Bogor: IPB Press)
- [9] Gooberman G L 1968 *Ultrasonic Theory and Application* (London: The English Universities Press Ltd)