

Kinetics of Changes in the Quality Parameters of Fresh Snake Fruit (*Salacca edulis* Rainw) During Storage

Satria Bhirawa Anoraga^{1,*} Nursigit Bintoro²

¹Agroindustrial Program, Departement of Bioresources and Veterinary, Vocational College, Universitas Gadjah Mada, Yogyakarta, Indonesia

²Biosystem and Agricultural Engineering Department, Faculty of Agriculture Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia

*Corresponding author Email: anoraga_584@yahoo.co.id

ABSTRACT

The effects of storage at different room RH-temperature treatment and packaging method conditions on Snake Fruit (*Salacca Edulis* cv. 'Pondoh') quality parameters, such as moisture content, brix (%), and fruits stress, were investigated. Packaging and storage method had impact significantly on the quality parameters of snake fruit. Significant alterations in snake fruit moisture content, brix (%) and fruit stress were observed. The Arrhenius equation could described the effect of packaging and storage method, especially on moisture content. These result represent a good predictive tool for snake fruit moisture content during storage.

Keywords: kinetic model, packaging, arrhenius, shelf life, prediction

1. INTRODUCTION

Snake fruit is one of the potential export commodities that grew 28 percent to 1,233 tons in 2018. Snake fruit exports to meet markets in Asia and other countries. Snake fruit 2018 exports of 1,233 tons were up 28% compared to 2017 of 965 tons [1]. Whereas snake fruit export destination countries are China, Cambodia, Malaysia, Singapore, Thailand, Saudi Arabia, United Arab Emirates, Timor Leste, Netherlands, Qatar, Hong Kong, Germany and the United Kingdom [2]. That's why the agricultural sector contribution to Indonesian GDP in 2013 has been about 14.43%, which is the second largest after the manufacturing sector [3].

The quality of fresh snake fruit is mainly determined by moisture content, total soluble solid (%brix), and fruit stress. Snake fruit texture and sweetness are the first external characteristic which determines the degree of consumer acceptance. Important quality changes occurs at various stages of snake fruit treatment and storage. Fresh snake fruit do not have a long shelf life and easily suffered damage because of the snake fruit contains levels of about 78%, thus it needs special handling to maintain the quality of snake fruit. In addition to the levels of moisture that is sufficiently high, the snake fruit has tannin compounds

that give a sense of *sepat* and change the color of chocolate when exposed to the air. This taste is the obstacle in marketing snake fruit on the international market [4].

Kinetic theory is the basis for explaining the rate of various processes and changes that occur during food processing and storage. The use of kinetics in the food sector is the application of kinetic principles used in chemical reactions [5]. Kinetics information can also be used in the planning process, the development of products, and storage of materials of food including estimation of shelf life. Some models can be used to guess the shelf life one product among others: models Labuza, a model time half and models Arrhenius [6].

Mathematical equations are required to determine dynamic changes, which can identify and consider several factors that affect the snake fruit quality parameters. Temperature and humidity as external factors have great influence on the deterioration of snake fruit during storage. The influence of other parameters such as packaging also evaluated. There are no publications with data describing changes in such a big group of physicochemical and sensory factors during the storage of snake fruit at different packaging and storage method. The purpose of this study was to

determine the value of the reaction rate constant (k) and activation energy (Ea) on several quality parameters of salak fruit during storage. This value was used to calculate the kinetic model using the Arrhenius equation, as a predictive tool to measure changes in quality parameters during storage of salak fruit using different packaging and storage methods.

2. MATERIALS AND METHODS

2.1 Samples and storage condition

Snake fruits (*Salacca Edulis* cv. 'Pondoh') obtained from "Salacca Tourism Village" Turi, Sleman, Yogyakarta, Indonesia, which already have maturity for commercial. A single snake fruit was packaged into two variation, vacuum and non vacuum, and a natural bunches as control. The samples were put in chamber which divided in four variation with different condition of temperature and humidity: humidified room, cool storage, and cooled humidified room, and ambient room as control. The chambers for humidified and cooled humidified room were made from plywood and covered by stereofoam. Humidified room have a RH minimum at 90% got from atomized aquades using high compressor. Cool humidified room have a temperature and RH minimum at 20-25°C and 90% got from air conditioner and atomized aquades. Cool Storage temperature were set in minimum 18°C [7].

2.2 Physical determination

Moisture content was analyzed using gravimetric method. Brix (%) was measured using Atago hand refractometer capacity 0-85%. Fruit stress were measured using compress test equipment. Analysis of variance (ANOVA) was carried out using the SPSS 19.0 software. ANOVA tests were performed for all experiments at 95% confidence interval.

2.3 Data analysis

The significance of variability factors to the measured effect was determined by means of analysis of variance (ANOVA). The statistical significance level was $p < 0.05$. The SPSS 16.0 and Excel Statistical software was used for statistical analyses.

Quality parameters during storage was analysed by means of a linear regression in the first order reaction. The most accurate fit was confirmed by the determination coefficient— R^2 . The relations between weight loss, moisture content, brix, fruit stress and

storage time can be expressed with the following mathematical equations:

$$M(t) = M_0 \times \exp(-kt) \quad (1)$$

At the next stage the Arrhenius equation parameters: activation energy (Ea) and reaction rate constant (k) were calculated for all the quality characteristics of snake fruit. The logarithmic form of the Arrhenius equation was used for this purpose

$$\ln k = \ln A - \left(\frac{E_a}{RT}\right) \quad (2)$$

where k—reaction rate constant; A—pre-exponential factor; Ea—activation energy [J/mol]; R—gas constant [8.314 J/K mol]; T—absolute temperature [K].

The Arrhenius Eq. (2), activation energy value, reaction rate constant and Eqs. (1) were used to prepare kinetic models of changes in the quality parameters during storage. The model was verified with the determination coefficient R^2 applied to the values of estimated and observed quality parameters.

3. RESULT AND DISCUSSION

3.1 Moisture content

Snake fruit has a high moisture content. In the storage process, moisture content decrease every day. It was caused by the evaporation on the skin of fruit. In addition, the harvested fruits still have respiration process. This study have investigated about moisture evaporation during the storage process.

The constant rate reaction for snake fruit quality attribute was calculated using analysis regression linear. Correlation between $\ln k$ and $1/T$ were presented in Figure 1. Figure 1 shows the regression equation for shrinkage of moisture content. The order reaction for moisture content changes on snake fruit was determined based on the R^2 value of the equation regression. The higher value of R^2 indicates that the mathematical model will be more accurate in predicting the quality value [8] which is presented in Figure 2. The highest R^2 value was obtained in the calculation of the predicted moisture content of 0.9731. This indicated that the model used was accurate enough to determine the moisture content of salak fruit. Table 1 shows the regression values of k, Ea, and R^2 on changes in moisture content, % brix, and stress of snake fruit during storage.

Changes in moisture content during storage were analyzed using the kinetics of changes in moisture content. The value of k (reaction rate constant) for each

storage condition was presented in Table 1. The k value rised due to an temperature increase in storage for all packaging methods [9]. Ambient room storage conditions have the highest k values for all packaging methods (bunched, plastic PP, and vacuum). It shows that the rate of change in the water content of salak fruit in the ambient room was more quicly than other conditions. It is caused by respiration and transpiration process still continues in the snake fruit during storage. The increasing of storage temperature causes the transpiration process to grow up, so that the rate of water loss and weight loss rise up. [10].

Ea value indicates the energy needed for some reaction which affect quality change on snake fruits [11]. Based on Table 1, the packaging method using polypropylene (PP) plastic has the highest Ea value. It shows that the snake fruit using PP plastic has a lower level of water content decrease. It can be said that the water content of snake fruit using PP plastic was more stable than other packaging methods. Polypropylene (PP) plastic is one of the packaging that is not easily torn and passed (impermeable) by gas and water vapor, so that water vapor from snake fruit did not not easily come out. [12].

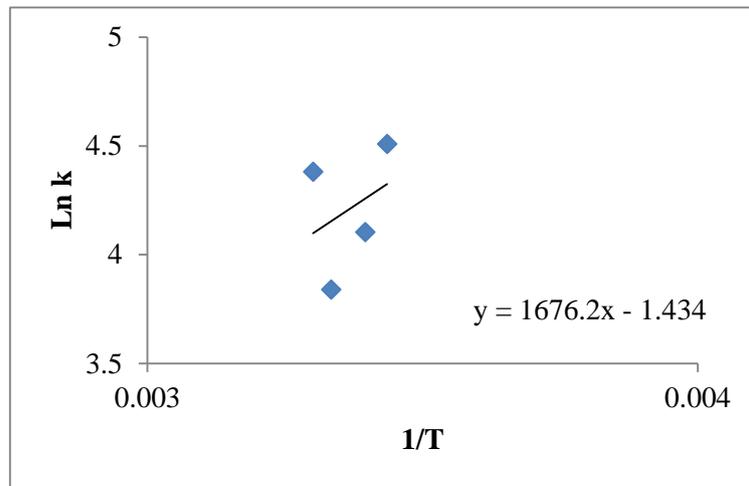


Figure 1. Example graphic 1 / T vs. Ln k changes the water content of snake fruit bunches

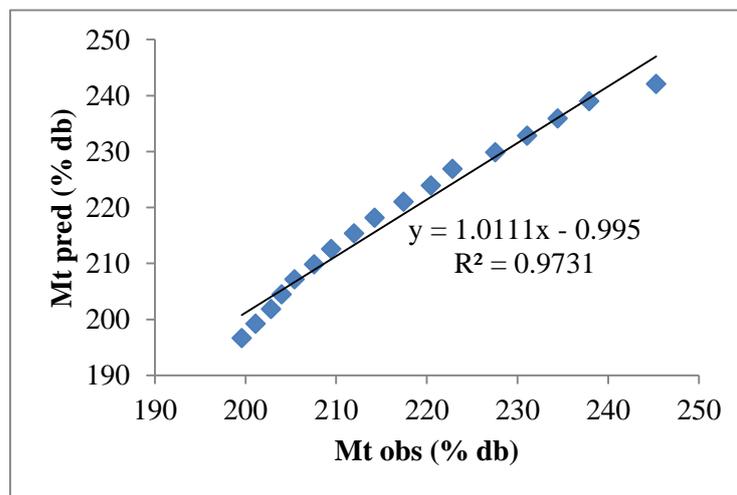


Figure 2. Example of chart water content observed vs levels of prediction sample bunches room cold (cold storage)

3.2. Brix (%)

In the initial of storage, the total soluble solid of each sample were around 19-22%. This was influenced by the condition or age of snake fruit when harvested. During the process of ripening fruit, total soluble solids increases due to reshuffle and cleavage of polymer carbohydrates especially starch into sugar, so that the content of total soluble solid in the snake fruit was getting increased [13].

Table 1 shows that the vacuum packaging method has the highest Ea value. It shows that the value of % brix in the vacuum packed is stable [12], so sample quality decline was slower during storage [9]. Packaging in vacuum can protect the product from the exchange of gas or water vapour from the outside, to prevent the entry of insects and little animals in the container during storage, prevents mold growth and heat formation which reduces excess moisture [14].

Table 1. Reaction rate constant, k, and activation energy, Ea, of snake fruit during storage

Quality Attributes	Pakckage method	Storage condition	k	Ea
Moisture Content	Bunched	humidified room	0,011	13927.6
		cool storage	0,012	
		cooled humidified room	0,016	
		ambient room	0,019	
	Plastic PP	humidified room	0,003	61768.2
		cool storage	0,0004	
		cooled humidified room	0,002	
		ambient room	0,004	
	Vacuum	humidified room	0,001	35143
		cool storage	0,0004	
		cooled humidified room	0,002	
		ambient room	0,002	
Brix%	Bunched	humidified room	0.017	27.947
		cool storage	0.030	
		cooled humidified room	0.099	
		ambient room	0.015	
	Plastic PP	humidified room	0,09306	274.064
		cool storage	0.056	
		cooled humidified room	0,07847	
		ambient room	0,10208	
	Vacuum	humidified room	0.096	385.418
		cool storage	0.012	
		cooled humidified room	0.060	
		ambient room	0.063	
Stress	Bunched	humidified room	0.019	3.224
		cool storage	0.019	

		cooled humidified room	0.017	
		ambient room	0.018	
	Plastic PP	humidified room	0.014	10.147
		cool storage	0.015	
		cooled humidified room	0.012	
		ambient room	0.015	
	Vacuum	humidified room	0.011	28.387
		cool storage	0.010	
		cooled humidified room	0.011	
		ambient room	0.011	

3.3. Stress

Some factors that influence the stress level of snake fruit are the age of snake fruit and the time of storage. The longer of storage, the texture of the material will also change. The older age of fruit, the hardness of the fruit will decrease. The respiration and transpiration process still continues, cause considerable loss of moisture content. So, the size and pressure of the cell contents against the cell walls will be reduced, then the texture on the snake fruit becomes soft [15]. The stress of a material is one of the parameters for the quality attribute of product texture.

The value of the energy activation (Ea) and constant rate of reaction (k) was used to prepare a model kinetic that allows the rate of change in the quality of snake fruit during storage. Based on Table 1 shows that the vacuum packaging method has the highest Ea value than the bunched packaging method and PP plastic. This shows that the stress level of snake fruit were packed in vacuum has a stable value [12]. The quality degradation of the snake fruit were packed in vacuum more slowly than other packaging methods. Packaging vacuum can inhibit the circulation of air and water vapor which causes softening on the snake fruit texture [16].

4. CONCLUSION

Snake fruit with vacuum packed have highest energy activity (Ea) value for brix% and stress parameters. Meanwhile, the Ea value of bunched snake fruit (unpacked) tends to be the lowest. The value of the reaction rate constant (k) for all parameters fluctuates.

The highest constant value (k) occurs in the vacuum packed snake fruit stored in ambient room. Determination of the moisture content prediction has the highest R² value 0.9731. This shows the model has quite good accuracy for moisture content prediction.

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