APPLICATION OF ACCELERATED SHELF LIFE TEST (ASLT) METHOD FOR SHELF LIFE DETERMINATION OF PINEAPPLE HONEY JUICE: A SUSTAINABLE APPROACH TO ENHANCE FOOD SECURITY

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Abstract - Pineapple is a highly perishable horticultural commodity, generally consumed fresh and prone to spoilage within five days at room temperature. To reduce post-harvest losses and support sustainable food availability, processing into value-added products such as juice is required. Shelf life information is essential before commercialization to ensure product safety, quality, and consumer trust. This study determined the shelf life of pineapple juice using the Accelerated Shelf Life Test (ASLT) method. Pineapple juice was processed, packaged, and stored at chilling temperature (5 °C) and room temperature (30 °C). Sensory attributes, including color, taste, and aroma, were evaluated as critical parameters. The ASLT method accelerates quality changes under controlled conditions to estimate shelf life more efficiently. Results indicated that pineapple juice stored at 5 °C maintained acceptable quality for up to seven days, whereas storage at 30 °C significantly reduced shelf life. Findings highlight the importance of appropriate storage and processing in extending product shelf life, minimizing food waste, and supporting sustainable food security.

Keywords: *Pineapple Juice, Shelf-life, ASLT method, Flavour, pH*

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1. INTRODUCTION

Pineapple (*Ananas comosus* (*L.*) Merr. Family: Bromeliaceae) is one of the most important commercial fruit crops in the world. Known as the queen of fruits due to its amazing flavor and taste. Pineapples are produced all year round. This fruit is very easily damaged. Many pineapples are wasted due to spoilage when pineapples are stored for long periods of time without processing. Therefore, there is a need to explore affordable and easy-to-apply food processing and preservation methods to convert abundant fruits into shelf-stable products such as juice, which is an easy, cheap and economically reliable alternative to reduce post-harvest losses. Fresh fruit juices have good microbial and enzymatic activity. The spoilage of fruit juice is basically caused by the presence of

osmophilic microflora, which causes fermentation and produces an unpleasant taste that occurs in fruit juice. Heat treatment and use of preservatives can be an effective way to inactivate microbial and enzymatic activity and extend shelf life. The shelf life of a food is the period of time under certain storage conditions, after manufacture or packaging, during which a food product will remain safe and suitable for use. The shelf life of pineapple juice can be determined by monitoring sensory changes that occur during storage so that measurable damage parameters for pineapple juice can be selected [1].

Shelf life is defined as the time span that a product has from production to consumption before the product experiences a decline in quality/damage and is unfit for consumption and this is related to food quality. Decreased product quality/damage can be seen from sensory and nutritional parameters. Shelf life testing will describe how long the product can remain at the same quality during the storage process. During the shelf life, the product must have nutritional content as stated on the packaging, the appearance, smell, texture, taste and function are maintained, and the product must be safe for consumption. Determining the shelf life of a product can be done using various testing methods. Changes in the quality of a product can be measured from physical, chemical changes or from the level of sensory acceptance [2]. The ASLT method is to determine product shelf life by accelerating quality changes in critical parameters. This method uses environmental conditions that can accelerate the reaction of decreasing the quality of food products. The ASLT method is a method of estimating shelf life by conditioning food products above normal storage conditions. In the ASLT method the temperature acts as a key parameter determining food damage, because the higher the temperature, the food damage will be faster. The correlation between temperature and speed of deterioration can be seen using the Arrhenius equation [3].

Product shelf life can be estimated in various ways, including using kinetics such as the half-life model and the Arrhenius model. The ASLT method applies reaction kinetics with the help of the Arrhenius equation. The Arrhenius model has several assumptions, including changes in quality factors are only determined by one type of reagent, there are no other factors that cause changes in quality, the quality change process is considered not to be a result of previous processes, the storage temperature is considered constant [4].

Several studies have been carried out regarding the development of shelf life for various methods. Research [5] shows that making apple juice using the HPCD method produces statistical analysis for °Brix, pH and color data showed no differences between the untreated and HPCD treated samples in the first 2 weeks of storage at 4°C. These results emphasize the potential use of HPCD in industrial applications. Research [6] show that spectrophotometric method has been developed for the quantitation of 5-hydroxymethyl furfural (5-HMF) levels in canned malt drinks and fruit juice drinks sampled. 5-HMF levels in fruit juice samples (A1–A10) were between 0.132 mg/ml and 0.438 mg/ml, and these levels were shown to be comparable (t 2.200; p 0.0553) to the contents in the canned malt samples (M1–M10) which were between 0.3140 mg/ml and 0.7170 mg/ml. The study failed to show any dependence of 5-HMF levels on the composition of the product as well as the manufacturing process adopted. The length of storage did also not signicantly aect the 5-HMF levels in the products. Furthermore research [7] show that an accelerated shelf life test (ASLT) was conducted, and various quality indicators were measured during this time, such as: pH, titratable acidity, colour, Total Aerobic Count (TAC) and sensory analysis. The test was performed on smoothie beverages purchased from Romanian market for 24 days, the samples being stored at three

different temperatures: 5°C, 10°C and 15°C. The fruit smoothies had an estimated shelf life of about 57 days (at 5°C) and 50 days (at 7°C) using the Arrhenius equation and an estimated shelf life about 49 days using the Q10-Rule, after extrapolating the data to real temperature conditions.

This study aimed to determine the shelf life of pineapple juice products more quickly and accurately by testing the pH value and sensory attributes (color, aroma, taste, and appearance) on products stored at chilling temperature (5℃) and room temperature (30℃) using the ASLT method. Beyond the scientific estimation, this research highlights the role of shelf life determination in supporting sustainability and food security. Accurate shelf life prediction reduces food losses and waste, promotes the efficient use of local agricultural commodities, and supports smallholder farmers by adding value to perishable crops like pineapple. By processing pineapples into shelf-stable juice, this study contributes to sustainable food systems while enhancing food availability, accessibility, utilization, and stability—the four pillars of food security. Thus, the application of ASLT not only provides technical insights but also strengthens sustainable practices and resilience in the food supply chain.

2. EXPERIMENTAL

2.1 Material and methods

2.1.1. Preparation of pineapple juice

The research was carried out at home in Surabaya at November 2023. The material used is pineapple. The stages of making fruit juice are presented in Figure 1. The process of making fruit juice from pineapple is as follows:

a. Selected pineapple fruit fully ripe and not damaged mechanical and microbiological.
b. The fruit is peeled and the pulp is taken, then blanched by steaming for 10 minutes.
c. The fruit is crushed into fruit pulp.
d. The fruit juice is then pasteurized using the pasturizer is then packaged in plastic bottles, where each bottle contains 100 ml fruit juice. Storage is done in two temperatures, namely 5℃ and 30˚C. There is 1 bottle of fruit juice for each storage temperature. Observation during storage is carried out at the beginning of storage or day 0 to day 7. The flow fiagram of pineapple juice production can be seen in Figure 1.

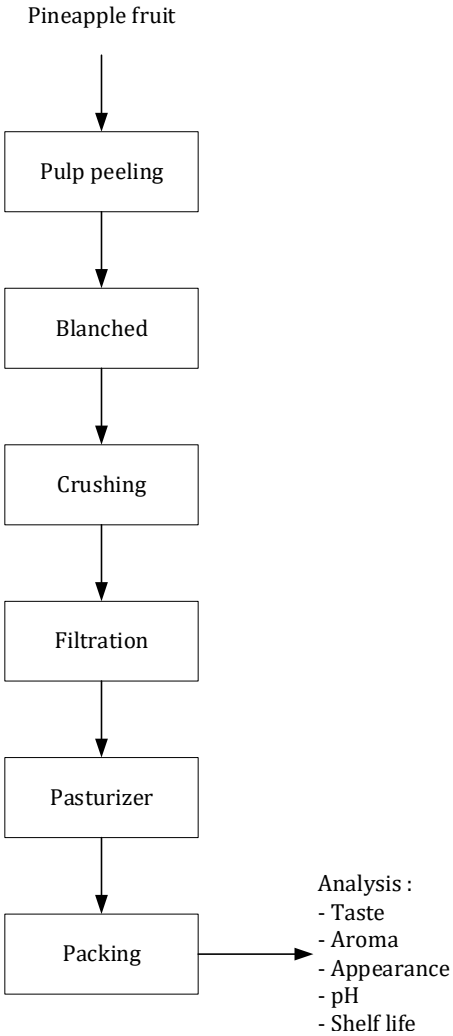


Figure 1. Flow Diagram of Pineapple Juice Production

2.1.2. Accelerated shelf-life testing of pineapple juice [ASLT]

The physicochemical properties data obtained were plotted against time, then the linear regression equation was calculated for the three acceleration temperatures, using the equation y = a + bx, where y = Physical properties of FD durian, x = storage time (days), b or k = rate of change. The value of b is also called the slope, which is the rate of deterioration. Zero order is determined by relating between the physical value (At) and the storage time (t), while the first order is calculated by relating ln value (ln At) with storage time (t). The degradation of the zero-order is expressed as the following equation:

$$\boldsymbol{A_t - A_0 = -kt} \quad (1)$$

Where At = Amount A at time t, A_0 = The initial number A, k = rate of deterioration and t = storage time

The equation for quality degradation with time first order is formulated by the equation:

$$\ln A_t - \ln A_0 = -kt \quad (2)$$

After obtaining the slope, intercept, and R^2 (zero order and first order), then the equation that has the largest R^2 was chosen for calculating the product shelflife using the Arrhenius Model:

$$\ln k = \ln k_0 - \left(\frac{E_a}{R}\right)\left(\frac{1}{T}\right) \quad (3)$$

Where ln k_0 = intercept, Ea/R = slope, Ea = activation energy, R = ideal gas constant = 1.986 cal/mol ˚K and T = temperature (˚K)

The relationship between the ln k and (1/T) was formed as a graph. The K_0 and the Ea were obtained from the graph. The key parameters were determined from the smallest activation energy (Ea). The shelf-life of the product was estimated by calculating the difference between the initial rate (A_0) and the value the rate at a certain time (At) using the following equation:

$$t_s = [\ln \frac{N_0 - N_t}{kT}] \quad \text{for first order (4)}$$

$$t_s = \frac{N_0 - N_t}{kT} \quad \text{for zero order (5)}$$

Where ts = storage time, N_0 = the initial rate at t_0, Nt = the rate after storage time t (critical limit) and KT = k at storage temperature T. [8].

3. RESULT AND DISCUSSION

3.1 pH Value Based on Storage Time

From the research that has been carried out, the pH measurement results for each variable decreased along with the length of storage time. The decrease in pH at the storage temperature variable using room temperature (30℃) tends to be greater than the pineapple stored at refrigerated temperature (5℃). This can happen because microbial growth and metabolism at room temperature tends to be faster than at refrigerated temperatures [9]. The results of microbial metabolism generally produce several new substances, including acid [10].

Table 1. pH values based on storage time.

Storage time (days)	pH in temperature 5℃	pH in temperature 30℃
0	3,85	3,83
1	3,74	3,72
2	3,63	3,6
3	3,52	3,58
4	3,41	3,46
5	3,3	3,34
6	3,28	3,22
7	3,16	3,1

3.2 Shelf life calculation

The pH value that has been identified is then converted into a reaction graph of order zero and order 1. This aims to determine the reaction order that will be used.

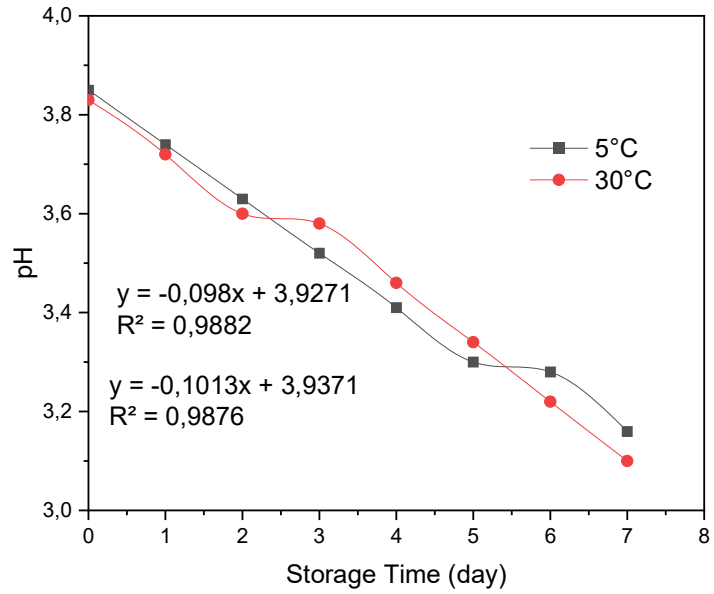


Figure 1. Zero order reaction graph. Effect of Storage Time on pH at varying temperatures

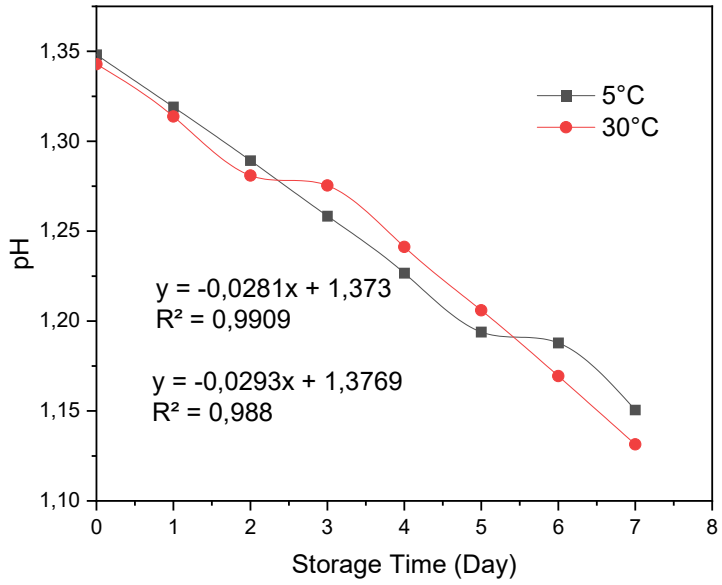


Figure 2. First order reaction graph. Effect of Storage Time on pH at varying temperatures

From Figure 1 and Figure 2, it can be seen that the R^2 value in the 1st order reaction is greater (closer to 1) than in the 0th order. So the product shelf life calculation in this study is based on the 1st order reaction. Based on calculations using the 1st order equation, the value of k (quality reduction constant) in Table 2 and plotting on a graph as in Figure 3.

Table 2. k value (quality degradation constant)

Temperature (°C)	T (K)	1/T (K)	Regression Equation	a, indicates k	b	ln k
5	278	0,003597	y = -0,0281x + 1,373	0,0281	1,373	-3,57199
30	303	0,0033	y = -0,0293x + 1,3769	0,0293	1,3769	-3,53017

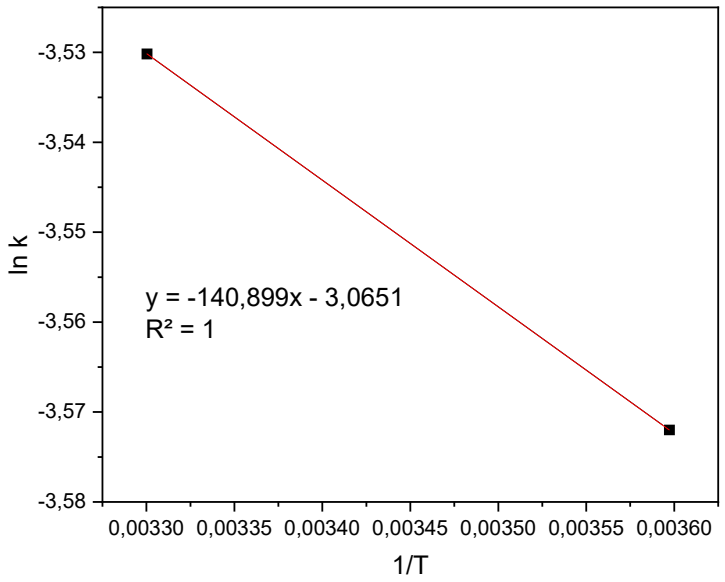


Figure 3. Graph of ln k vs 1/T

From Figure 3, a linear equation is obtained (y = 0.0418x – 3.6138). Based on this equation, a graphic equation is obtained which is substituted into the Arrhenius equation, so that the data in table 3 is obtained.

Table 3. Calculation results using the Arrhenius equation

Temperature (°C)	T (K)	1/T (K)	ln k0	Ea/R	ln k	k
5	278	0,003597	-3,6138	0,0418	-3,61395036	0,026945193
30	303	0,0033	-3,6178	0,0418	-3,617937954	0,026837961

The data obtained from the equation is used to determine K Arrhenius for each temperature variable. It was found that K Arrhenius at a temperature of 5°C was 0.026945193 and K Arrhenius at a temperature of 30°C is 0.026837961. The Arrhenius K results obtained were then included in the shelf time calculation and the product shelf life was obtained as shown in table 4.

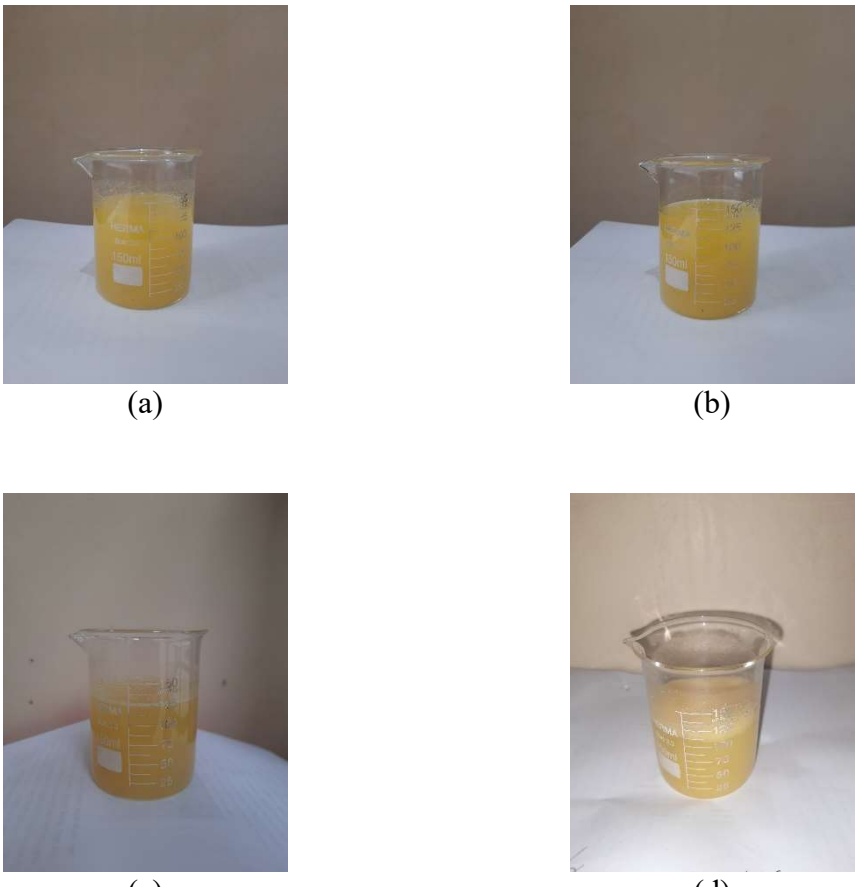
Table 4. Product Shelf Life

Temperature (°C)	k	N0	Nt	ln N0	ln Nt	ln N0 - ln Nt	ts
5	0,026945193	3,85	3,16	1,348073148	1,150572028	0,197501121	7,329735
30	0,026837961	3,83	3,1	1,342864803	1,131402111	0,211462692	7,879238

The product is stored at 5°C for 7.3 days and the product shelf life at 30°C is 7.8 days. The shelf life of this product is considered very short when compared to products on the market because there are no preservatives added to the product analyzed in this experiment. However, both have the same shelf life in 7 days, this shows that pH does not affect the shelf life of the pineapple juice product in this study, so further research is needed regarding other parameters that influence the shelf life of pineapple juice.

3.3 Sensory Test

Color, aroma, and taste criteria were tested in sensory testing of pineapple because they might be used to visually demonstrate a change in product quality. The product is stored in 2 different temperatures and tested sensory every day. Product photos are shown in the figure 4.



(a) (b)

(c) (d)

Figure 4. Product photos (a)Pinapple Juice at 5°C on 1st day, (b) Pinapple Juice at 30°C on 1st day, (c) Pinapple Juice at 5°C on 7th day, Pinapple Juice at 30°C on 7th day

Observations based on color, on 1st day pineapple juice stored at temperature 5°C have the same color with pineapple juice stored at temperature 30°C, while on 7th day pineapple juice stored at temperature 30°C had a darker color than pineapple juice stored

at temperature 5℃. Observations based on aroma, on 1st day pineapple juice stored at temperature 5℃ have the same aroma with pineapple juice stored at temperature 30℃, while on 7th day pineapple juice stored at temperature 30℃ had more sour aroma than pineapple juice stored at temperature 5℃. On 7th day pineapple juice stored at temperature 30℃ foam also appears. Observations based on taste, on 1st day pineapple juice stored at temperature 5℃ have the same taste with pineapple juice stored at temperature 30℃, while on 7th day pineapple juice stored at temperature 30℃ had bitter sour taste than pineapple juice stored at temperature 5℃.

4. CONCLUSIONS

Based on the results of observations that have been made, the results were obtained that temperature and pH can affect the shelf life of the product. The product that stored at 5℃ have a shelf life for 7.3 days and the product that stored at 30℃ have a shelf life for 7.8 days by using ASLT methods. The shelf life of this product is considered very short when compared to products on the market because there are no preservatives added to the product analyzed in this experiment.

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