The shelf life of kawista fruit salad (rujak) dressing using Accelerated Shelf-Life Testing (ASLT) method

M Hayati¹, N Arpi²*, Z F Rozali²

¹Graduate student at Master of Agricultural Industry Technology Department, Faculty of Agriculture, Universitas Syiah Kuala, Jl. Tgk. Hasan Krueng Kalee No.3, Darussalam, Banda Aceh 23111, Indonesia
²Agricultural Product Technology Department, Faculty of Agriculture, Universitas Syiah Kuala, Jl. Tgk. Hasan Krueng Kalee No.3, Darussalam, Banda Aceh 23111, Indonesia

*Email: normalina.arpi@unsyiah.ac.id

Abstract. Rujak kawista sauce is one of the typical Indonesian foods made from palm sugar, tamarind, bird’s eye chili, nuts, and special fruits of kawista to enhance the flavour. There is no information about the shelf-life of rujak kawista sauce to date. Therefore, it is necessary to conduct a study on the storage time of the rujak kawista sauce to determine the product's shelf life. This study used the ASLT method to determine the shelf life of rujak sauce. The sauce was stored at temperatures of 30°C, 40°C, and 50°C within 21 days storage time and was analysed every seven days. The analytical methods used to support the ASLT method are TBA, moisture content, FFA, total dissolved solids and pH. The result showed that TBA value was 0.046-0.19 mg malonaldehyde/kg, moisture content was 16.68-20%, FFA was 0.66-0.80%, total dissolved solid was 17.9-21.1°Brix, and pH was 3.1-3.5. Based on Arrhenius calculations, the shelf-life of rujak kawista sauce was two months.

1. Introduction

Rujak sauce is a processed food whose main ingredients use natural ingredients such as palm sugar, tamarind, chili, salt, peanuts and other complementary additives. Particularly in Aceh Besar, the additional ingredient used is kawista fruit as a flavour enhancer and thickener. The people of Aceh are very fond of consuming rujak because it not only contains nutrients but also contains components that are beneficial to the body’s health, namely alkaloids, saponins, phenols and flavonoids which are antioxidants [1].

Rujak sauce is one of the foods that tend to be non-acidic and has a high-water content, served in a watery state and mild temperature. The processing is usually done without using gloves or tongs. Hence, the rujak sauce does not last long and a heating process is needed to make it more durable[2]. Heating rujak kawista sauce aims to reduce the water content and the number of microbes to extend the shelf-life. This study aims to examine the changes in the physical and chemical properties of rujak kawista during storage time. The shelf-life of rujak sauce was estimated using the Arrhenius model of the ASLT method which is widely used for estimating the shelf life of perishable food products[3,4].
Arrhenius model simulates the acceleration of product spoilage under conditions of high-temperature storage above normal storage temperatures.

2. Materials and methods

2.1. Materials
The materials used for this study were: kawista fruit, palm sugar, bird’s eye chili, granulated sugar, salt, water, nuts, plastic bottles. The materials used for analysis were neutral alcohol, phenolphthalein (PP), NaOH, HCL, TBA, and distilled water.

2.2. TBA Analysis
TBA analysis was performed once a week for 35 days. Samples were stored at three different temperatures of 29 °C, 40 °C, 50 °C for 21 days. Five grams of samples and 50 ml of distilled water were mixed and then poured into a 250 ml distillation flask with the addition of 47.5 ml of distilled water and 2.5 ml of 4 M HCL until the pH was 1.5. The distillation flask was attached to the distillation apparatus and heated until 50 ml of the distillate was collected. The collected distillate was poured into an Erlenmeyer followed by the addition of 5 ml of TBA reagent (0.02 g of TBA solution into 100 ml of 90% glacial acetic acid). Then, the glass containing the solution was heated over boiling water for 35 minutes and cooled using running water. Then the absorbance was measured with a wavelength of 528 nm.

2.3. Methods
Analysis of the shelf life of rujak kawista sauce used the ASLT method with the Arrhenius model approach. The analysis of rujak kawista sauce was TBA analysis [5], free fatty acid (FFA) [6], water content [7], total dissolved solids, and pH [8,9].

2.4. Kinetics prediction of rujak kawista sauce stability using ASLT method with Arrhenius model [10]
This study was conducted to estimate the shelf life of rujak kawista sauce using the ASLT (Accelerated Shelf-Life Testing) method. This method was carried out by storing the rujak kawista sauce in high temperatures to accelerate the reactions of quality decrease of the product. The product was kept in 30°C, 40°C, 50°C temperature for 28 days and was analysed every seven days.

Quality degradation measurements were carried out to determine the stability of the rujak kawista sauce by using the Arrhenius method. According to Nambi et al. (2016), the degradation kinetics can be calculated based on the zero-order with the following equation:

\[ A_t = A_0 - Kt \]  

(1)

It can also be calculated based on order one with the following equation:

\[ \ln A_t = \ln A_0 - Kt \]  

(2)

Where:
- \( A_t \) = concentration or value at \( t \) time
- \( A_0 \) = concentration or initial value
- \( K \) = constant of deteriorating quality
- \( t \) = time

The effect of storage temperature on quality degradation was calculated by the Arrhenius method by plotting \( 1/T \) (temperature in kelvin scale) against \( \ln k \) (reaction constant which has been converted to \( \ln \) form). From the curve, the following equation was obtained:

\[ \ln k = \ln k_0 - \frac{E_a}{RT} \]  

(3)
Where:

\[ k_0 = \text{Arrhenius constant} \]
\[ R = \text{universal gas constant} \ (8.314 \text{ J/mol}) \]
\[ T = \text{temperature} \ (\text{K}) \]
\[ E_a = \text{activation energy} \ (\text{kJ/mol}) \]

\( k_0 \) denotes the constant deterioration stored at normal temperature, \( k \) represents the constant of degradation of one of the conditions used, while \( E_a/R \) is the gradient obtained from the Arrhenius plot. The calculation of the formula then resulting in the \( k \). Furthermore, the calculation of the product’s shelf life was using the equation:

\[
\text{t zero-order} = \frac{(A_0 - A)}{k} 
\]
\[
\text{t first-order} = \frac{(\ln A_0 - \ln A)}{k} 
\]

Where:

\( t = \) predicted shelf life (days)
\( A_0 = \) initial quality value
\( A = \) remaining value of product quality after \( t \) time
\( k = \) constant degradation at normal temperature

3. Results and discussion

3.1. Water content

Water is an essential component in food products because it affects the appearance, texture and taste of the food itself [11]. The water content can affect the material's durability because microorganisms are very easy to breed in it. Hence, the water content in food products should be as low as possible to maintain the quality [8].

The result showed that the water content of the **rujak kawista** sauce at week 0 was 18%. The first week's water content analysis obtained the range of 18%-20% with an average of 18.7%. The water content of the sauce in the third week ranged from 16.88%-18.18% with an average of 17.48%. The water content is classified as low due to the long cooking process which causes the sauce to become thick. The low water content is also assumed due to the water that was bound with the sugar.

![Figure 1. Water content of *rujak kawista* sauce.](image-url)
3.2. The pH of rujak sauce

The pH value indicates the level of acid and base of a product [12]. It leads to the change in the environmental conditions that determine the growth of microorganisms in the product. The result of the study showed that the pH value at week 0 was 3.50. The alteration in pH value during storage is as shown in Table 1.

| Temperature | Week 0 | Week 1 | Week 2 |
|-------------|--------|--------|--------|
| 30°C        | 3.5    | 3.55   | 3.31   |
| 40°C        | 3.5    | 3.54   | 3.33   |
| 50°C        | 3.5    | 3.54   | 3.45   |

Table 1 indicated that the longer the storage time, the more acidic the pH of the rujak kawista sauce would be. This finding is expected due to the conversion of sugar to acid. The acidic pH of rujak sauce can inhibit the growth of microorganisms. Thus, the rujak sauce has a longer shelf life.

3.3. Total dissolved solids

The value of dissolved solids in the rujak kawista sauce from week 0 to week two is as shown in Table 2.

| Temperature | Week 0  | Week 1  | Week 2  |
|-------------|---------|---------|---------|
| 30°C        | 17.9°Brix | 20.24°Brix | 20.25°Brix |
| 40°C        | 17.9°Brix | 19.25°Brix | 20.75°Brix |
| 50°C        | 17.9°Brix | 18.0°Brix  | 21.1°Brix  |

Total dissolved solids are the number of materials dissolved in a solution consisting of organic and inorganic compounds. This analysis aimed to determine the hygroscopic and activated carbon properties [9]. The value of total dissolved solids is directly proportional to the sugar content in a material. Therefore, the higher the sucrose (sugar) content in the sauce, the higher the total dissolved solids.

3.4. Free Fatty Acid (FFA) value for rujak kawista sauce

The FFA test serves to determine the free fatty acid content contained in the rujak kawista sauce [9]. The free fatty acids come from the addition of nuts in the sauce. Table 3 represents the FFA value of the rujak kawista sauce.

| Storage Time | FFA Value of Rujak kawista Sauce (%) |
|--------------|-------------------------------------|
|              | 30°C | 40°C | 50°C |
| Week 0       | 0.66 | 0.66 | 0.66 |
| Week 1       | 0.57 | 0.65 | 0.73 |
| Week 2       | 0.55 | 0.68 | 0.80 |

Table 3 indicated that the longer and higher the storage temperature, the higher the free fatty acids from the sauce. This result is thought due to intrinsic, extrinsic, and long storage factors. During storage, oils and fats undergo Physico-chemical changes caused by hydrolysis and oxidation processes. Improper storage for a long period can cause the breakdown of triglycerides in oils and fats.

3.5. The value of TBA for rujak kawista sauce

TBA analysis serves to determine the level of rancidity in a product. The longer the storage and the higher the temperature, the higher the TBA value because the free fatty acids have been oxidized [5,[13]]. The value of TBA in rujak sauce can be seen in Table 4.
Table 4. TBA value of *rujak kawista* sauce.

| Storage Time | TBA value of *rujak kawista* sauce (mg malonaldehyde/kg) |
|-------------|----------------------------------------------------------|
|             | 30°C | 40°C | 50°C |
| Week 0      | 0.046| 0.046| 0.046|
| Week 1      | 0.046| 0.14 | 0.18 |
| Week 2      | 0.047| 0.16 | 0.19 |

3.6. Arrhenius calculation

In this study, the critical point of the *rujak* sauce is rancidity. The rancidity of the *rujak* sauce was measured by using TBA analysis. The determination of the order of the reaction was carried out to observe the rate of change in the quality of the shelf-life parameters. Zero reaction order is selected if the rate of deterioration is constant or linear, while one is selected if the rate of deterioration is logarithmic or exponential [14,15]. The reaction order was chosen by looking at the linear regression equation at each temperature of observation. The value of $R^2$ that is close to one is used to determine the order of the reaction. The order of reaction for the estimation of shelf life can be seen in Table 5.

![Graph](image_url)

**Figure 2.** Correlation between $\ln K$ TBA number with the temperature ($1/T$) of *rujak kawista* sauce.

Table 5. Arrhenius equation for TBA value.

| Order | Parameter | Temperature (1/T, K) | Equation           | $\ln k$  | $K$     | (Ao-At) | ln (Ao-At) | Shelf-life (days) |
|-------|-----------|----------------------|--------------------|----------|---------|---------|------------|-------------------|
| 0     | TBA       | 0.0033               | $y = -280.5x - 3.7157$ | -4.641   | 0.010   | 0.25166 |            | 26.096            |
|       | TBA       | 0.0032               | $y = -280.5x - 3.7157$ | -4.612   | 0.010   | 0.25166 |            | 25.335            |
|       | TBA       | 0.0031               | $y = -280.5x - 3.7157$ | -4.584   | 0.010   | 0.25166 |            | 24.642            |
| 1     | TBA       | 0.0033               | $y = -192.22x - 3.2002$ | -3.835   | 0.022   | 1.3796763 |          | 63.844            |
|       | TBA       | 0.0032               | $y = -192.22x - 3.2002$ | -3.814   | 0.022   | 1.3796763 |          | 62.563            |
|       | TBA       | 0.0031               | $y = -192.22x - 3.2002$ | -3.795   | 0.022   | 1.3796763 |          | 61.384            |

Based on the results of the calculations in Table 5, the shelf life of *rujak kawista* sauce on first-order ranged from 61-63 days or two months. The sauce with the longest shelf life is the one kept at the temperature of 30°C.
Figure 3 indicated that the longer the storage and the higher the temperature, the higher the rancidity of the rujak sauce. This finding is due to the oxidation of fat in the nuts in the rujak kawista sauce.

4. Conclusions
The study results found that the longer the rujak spice was stored, the more damaged occurred to the nutrients in the rujak kawista sauce. The study found that the longer the rujak kawista dressing, the more damaged the nutrients in the dressing. This is obtained from the results of TBA analysis which is the critical point of kawista rujak dressing. The TBA value is stored at high temperatures, the more rancid the rujak dressing becomes. It can be seen that the TBA value of rujak dressing in the control was 0.046 mg malonaldehyde/kg and in the second week there was an increase in the TBA value of 0.19 mg malonaldehyde/kg at a temperature of 50°C. This result came from the number of TBA which is the critical point of rujak sauce. The shelf life of rujak kawista sauce which was stored at 30°C is two months.

References
[1] Mulyati A H, Widiastuti D and Oktaviani L M 2018 Characterization of Durian Seed Flour (Durio zibhetinuss l.) and Estimation of its Self Life with Accelerated Self Life Testing (ASLT) Moisture Critical Method J. Phys. Conf. Ser. 1095
[2] Sakinah I and Yuwono S S 2015 PENGARUH KUALITAS PETIS UDANG DAN LAMA PEMANASAN TERHADAP SIFAT-SIFAT BUMBU RUJAK CINGUR INSTAN SELAMA PENYIMPANAN Effect Shrimp Paste Quality and Heating time on Properties Rujak Cingur Instant Seasoning during Storage 3 313–23
[3] Kurniadi M, Salam N, Kusumaningrum A, Nursiwi A, Angwar M, Susanto A, Nurhikmat A, Triiwiyono and Frediansyah A 2017 Shelf-life prediction of canned “nasi uduk” using accelerated shelf-life test (ASLT) -Arrhenius model AIP Conf. Proc. 1788
[4] Rasane P, Jha A and Sharma N 2015 Predictive modelling for shelf life determination of nutricereal based fermented baby food J. Food Sci. Technol. 52 5003–11
[5] Wahyuni S, Holilah, Asranudin and Noviyanti 2018 Estimation of shelf life of wikau maombo brownies cake using Accelerated Shelf Life Testing (ASLT) method with Arrhenius model IOP Conf. Ser. Earth Environ. Sci. 122

[6] Yuwono S S, Waziroh E and Illhamadi F 2019 Shelf life estimation of rujak cingur instant sauce using accelerated shelf life testing (ASLT) method IOP Conf. Ser. Earth Environ. Sci. 230

[7] Astawan M, Hermanianto J, Suliantari and Sugiyanto G S P 2016 Application of vacuum packaging to extend the shelf life of fresh-seasoned tempe Int. Food Res. J. 23 2571–80

[8] Apriliyanti M W, Nurdihati A and Ardiyansyah M 2020 Pendugaan Umur Simpan Jelly Kelor Instan Dengan Metode Accelerated Shelf Life Test (ASLT) Model Pendekatan Kadar Air Kritis J. Food Technol. Agroindustry 2 54–63

[9] Patil H, Shejale K P, Jabaraj R, Shah N and Kumar G 2020 Disinfestation of red flour beetle (Tribolium castaneum) present in almonds (Prunus dulcis) using microwave heating and evaluation of quality and shelf life of almonds J. Stored Prod. Res. 87 101616

[10] Pulungan M H, Sukmana A D and Dewi I A 2018 Shelf life prediction of apple brownies using accelerated method IOP Conf. Ser. Earth Environ. Sci. 131 3–8

[11] Amanda V, Sulaiman I and Yunita D 2019 Variety of packaging and estimated shelf life of Acehnese traditional food (pliek u) IOP Conf. Ser. Mater. Sci. Eng. 536

[12] Kamdem S S, Patrignani F and Elisabetta Guerzoni M 2007 Shelf-life and safety characteristics of Italian Toscana traditional fresh sausage (Salsiccia) combining two commercial ready-to-use additives and spices Food Control 18 421–9

[13] Muzaffar K and Kumar P 2017 Quality assessment and shelf life prediction of spray dried tamarind pulp powder in accelerated environment using two different packaging materials J. Food Meas. Charact. 11 265–71

[14] Tian H X, Zhang Y J, Chen C, Qin L, Xiao L Z, Ma H R and Yu H Y 2019 Effects of natural ingredients on the shelf life of chicken seasoning Food Chem. 293 120–6

[15] Kardile N B, Nema P K, Kaur B P and Thakre S M 2019 A Comparative Study of Suitability of Low-Density Polyethylene and Coextruded Laminate Pouches for Storage Stability and Shelf Life Prediction of Instant Puran Powder J. Packag. Technol. Res. 3 223–33