Shelf life estimation of rujak cingur instant sauce using accelerated shelf life testing (ASLT) method

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Abstract. Rujak cingur is one of Indonesian traditional cuisine. The process required to produce Rujak cingur sauce is time consuming. Manufacturing Rujak cingur instant sauce becomes an innovation to solve the problem. However, there is no information about shelf life of this sauce to guarantee its quality and safety. Therefore, it is necessary to estimate the shelf life of Rujak cingur instant sauce. The experimental method employed in estimating shelf life of Rujak cingur instant sauce is Accelerated Shelf Life Testing (ASLT). The temperatures used in this experiment were 30°C, 34°C, and 37°C. Parameters observed during the storage process were water content, Aw, fat content, FFAs, peroxide value, TBA value, and Total Plate Count. ANOVA testing results of sensory analysis as conducted by applying the spectrum method shows that storage time of Rujak cingur instant sauce affected salty taste, savoury taste, and rancid aroma of instant sauce. The estimation of shelf life of Rujak cingur instant sauce was performed by using the Arrhenius equation of: \( y = -10482x +31.864 \). The shelf life of Rujak cingur instant sauce at 25°C was 89 days based on limitation of total microorganism contamination in product and was 113 days based on panellist rejection.

1. Introduction

Rujak cingur is one of Indonesian specialties made of a mixture of ingredients such as: peanuts, shrimp paste, brown sugar, cayenne pepper, Batu banana, salt, tamarind and mineral water. The process of serving Rujak cingur takes around 10-15 minutes. The time required to make the sauce is considered less effective and is time consuming as Rujak cingur sauce needs to be prepared by traditional pounding method [1].

The demand of more convenient traditional food product with longer shelf life could be addressed such as by the innovation of an instant Rujak cingur sauce. Research related to the formulation of Rujak cingur instant sauce has been carried out by Karunia [2] and Sakinah [1]. Previously, another research had also been carried out to select methods and types of packaging as well as the addition of appropriate preservatives to optimize the storage capability of Rujak cingur instant sauce [3]. However, the determination of the shelf life of Rujak cingur instant sauce ingredients has not been studied. Therefore, this study aimed to examine the shelf life of Rujak cingur instant sauce by using the Accelerated Shelf Life Testing (ASLT) method with the Arrhenius approach, that use different temperature to accelerate damage of the product [4, 5].
2. Materials and Methods

2.1. Materials

The ingredients used in the manufacture of *Rujak cingur* instant sauce were peanuts, shrimp paste, brown sugar, *Batu* banana, cayenne pepper, tamarind, salt, sodium benzoate, and multilayer packaging as obtained from traditional markets in Indonesia. The materials used for analysis include: acetic acid, chloroform, potassium iodide, Na$_2$S$_2$O$_3$, starch solution, HCl, TBA reagent, ethanol, PP, NaOH indicator, PCA media, distilled water, petroleum ether, commercial citrus scent, acetic acid, vanilla aroma, caramel aroma, refined sugar, citric acid, refined salt (NaCl), pure caffeine, refined MSG (monosodium glutamate) and mineral water.

2.2 Determination on characteristics of rujak cingur instant sauce quality

As much as 25 g of *Rujak cingur* instant sauce was packed and then stored at 37°C. The characteristics of *Rujak cingur* instant sauce were assessed from regular observations for every 7-day time, starting from day 0 until the result was declined by the panelist. If declined, the final analysis presented the following results: the moisture content of the vacuum method [6], the TBA value of the spectrophotometric method [7], and the Total Plate Count [8].

2.3 Determination on shelf life of rujak cingur instant sauce

A 25 g of packed *Rujak cingur* instant sauce were taken and then grouped into three and was stored at 30°C, 34°C, and 37°C. Observations were made periodically every 7-day time at all three different storage temperatures. Observations were made through running the sensory testing by the 12 trained panellists and through running the tests on the characteristics of *Rujak cingur* instant sauce quality including: moisture content of vacuum method [6], TBA value of spectrophotometric methods [7], and Total Plate Count [8]. Furthermore, determination of shelf life is carried out by using the *Arrhenius* method.

3. Results and Discussion

3.1. Determination on characteristics of rujak cingur instant sauce quality

In determining the characteristics by estimating the shelf life of *Rujak cingur* instant sauce, it is necessary to analyze the parameters which affect the quality degradation at the beginning and end of storage. Observations were carried out periodically every 7-day time by the 12 trained panelists through product acceptance tests since day 0 storage, in which up to 50% more panelists reject *Rujak cingur* instant sauce.

The rejection of *Rujak cingur* instant sauce result by the panellists on the 28th day is used as a limit to determine the final quality characteristics (At). The characteristics of *Rujak cingur* instant sauce can be seen in Table 1

| Parameters                  | Initial Result (A$_0$) | Final Result (A$_t$) |
|-----------------------------|------------------------|----------------------|
| Moisture content (%)        | 22.87                  | 23.04                |
| Water activity              | 0.84                   | 0.82                 |
| Fat (%)                     | 12.73                  | 13.18                |
| Peroxide number (meq/kg)    | 1.88                   | 3.37                 |
| Free Fatty Acid (%)         | 2.75                   | 3.14                 |
| TBA Value (mg malonaldehyde/kg) | 2.11                | 33.63                |
| Total Plate Count (CFU/g)   | $1.8 \times 10^3$      | $1.65 \times 10^7$   |

3.2. Results of spectrum method sensory test

Evaluation during storage indicated that the attributes of *Rujak cingur* instant sauce had a significant effect on shelf life including salty taste, savory flavor and rancid aroma. Attributes of sweetness, sour taste, bitter taste, septic after taste, and spicy sensation did not present significant effect during the
storage time. All attributes of Rujak cingur instant sauce did not have a significant effect during storage temperature conditions.

3.3. Thio barbituric acid (TBA) value
The data plot, as observed from the TBA value of Rujak cingur instant sauce in three different storage temperature conditions, follows order one. The greater the value of $k$ in a parameter, the faster the reaction rate changes in the parameter [9]. The Arrhenius equation is obtained by plotting the relationship between $1/T$ and $\ln k$ of the order zero in linear regression equation. Linear regression presents that $y(\ln k) = -32295 (1/T) + 104.42$ with the coefficient of determination ($R^2$) of 0.9083 and the activation energy of the change in the value of TBA was 64138.8 cal / mol.K.

3.4. Water activities
Based on the order zero of linear regression equation and order one in the parameters, Rujak cingur instant sauce water activities during storage were at temperatures of 30°C, 34°C, and 37°C. Linear regression equation results of Arrhenius plot were based on the water activity parameters which were obtained by the formulation of: $y(\ln k) = -101574 (1/T) + 328.68$ with the determination value ($R^2$) of 0.8244. The value of $R^2$ presented that the factor of temperature or storage time had an effect on the water activity parameters as the value of $R^2$ was close to 1 or $R^2 = 1$ [10]. Activation energy required in changing the Rujak cingur instant sauce water activity parameters was 201726.70 cal / mol.K.

3.5. Total plate count
The observation of data plot for the TPC parameter follows the order zero of linear regression equation. During the storage, there is a linear increase in the Total Plate Count parameter. This is supported by an increase in the slope of the line in the plot of observational data of Rujak cingur instant sauce for the Total Plate Count parameter.

The linear regression equation obtained from the Arrhenius plot for changes in TPC in Rujak cingur instant sauce is $y(\ln k) = -10482 (1/T) + 31,867$ with a coefficient of determination of 0.916. Referring to the determination of coefficient value which is close to 1, it means that the temperature or storage time factor has an effect on the change of Rujak cingur instant sauce Total Plate Count. Change in Total Plate Count which occurs during storage requires activation energy of 20816.30 cal / mol.K.

3.6. Determination of shelf life
There are several criteria in selecting the most appropriate quality parameters important for determining the shelf life of the product [11], which include: 1) the highest quality parameter decreasing during storage as indicated by the absolute coefficient value or the greatest coefficient of determination ($R^2$); 2) the quality parameter being the most sensitive to temperature changes as can be seen based on the slope value in the Arrhenius equation or from the lowest activation energy (Ea); and 3) the existence of more than one quality parameter meeting the criteria, quality parameters having a shorter shelf life would be selected.

The parameter which has the lowest activation energy is the Total Plate Count parameter of 20816.30 cal / mol.K. Based on the value of activation energy, the total plate count parameter and the highest determination coefficient ($R^2$) are 0.9160. Therefore, Total Plate Count is used as a parameter in determining the shelf life of Rujak cingur instant sauce.

This study also refers to food security standard as related to the limit of contamination of microorganisms of $5 \times 10^5$ (Total Plate Count) in SNI 7388: 2009 09.2.4. Based on the maximum limit of microorganism contamination allowed to study the shelf life of Rujak cingur instant sauce, the study was stopped on the 21$^{st}$ day at 37°C storage with total contamination of microorganisms reaching $2.2 \times 10^6$. The calculation of shelf life of Rujak cingur instant sauce was conducted by using the Arrhenius equation parameter of Total Plate Count with microbial contamination limit as a basis for rejection, which is presented in Table 2.
Table 2. Calculation results of shelf life of *rujak cingur* instant sauce at various storage temperatures with TPC Parameters of less than ($<$) $10^6$.

| Temperature | k       | Shelf Life (day) |
|-------------|---------|------------------|
| °C          | K       |                  |
| 25          | 298     | 0.03665057       | 89.29         |
| 30          | 303     | 0.06548622       | 49.97         |

Table 2 presents the information that at storage temperature of 25°C, the shelf life of *Rujak cingur* instant sauce reached 89 days and at storage temperature of 30°C, the shelf life of *Rujak cingur* instant sauce only lasted for 49 days. This indicates that the lower storage temperature the longer the shelf life of *Rujak cingur* instant sauce.

In the study of shelf life, it was found that there was no rejection of *Rujak cingur* instant sauce by the panellists in the 21st day. Therefore, organoleptic analysis was further continued until 50% panellists decided that the characteristics of the *Rujak cingur* instant sauce was unacceptable. Panellist rejection upon the result of the study occurred on the 28th day; hence, the study to estimate the shelf life of *Rujak cingur* instant sauce was halted. The estimation of the shelf life of *Rujak cingur* instant sauce based on panellist rejection is presented in Table 3.

Table 3. Calculation results of shelf life of *rujak cingur* instant sauce at various storage temperatures with the panellists parameter.

| Temperature | k       | Shelf Life (day) |
|-------------|---------|------------------|
| °C          | K       |                  |
| 25          | 298     | 0.03665057       | 113.19        |
| 30          | 303     | 0.06548622       | 63.35         |

Table 3 indicates that the shelf life of *Rujak cingur* instant sauce at 25°C and 30°C were 113 days and 63 days, respectively. This result means that the lower storage temperature will prolong the shelf life of *Rujak cingur* instant sauce. The increase on storage temperature may lead to a greater reaction speed as indicated by a sharp slope of the line and the constant decreasing rate of reaction quality [12].

4. Conclusions

Three determinants of the decrease in the quality of *Rujak cingur* instant sauce ingredients are: water activity parameters, TBA values, and Total Plate Count. The $R^2$ values and activation energies of those three parameters are 0.8244 and 201726.70 cal / mol.K; 0.9083 and 64138.80 cal / mol.K; and 0.9160 and 20816.30 cal / mol.K, respectively. Based on the highest $R^2$ value with the lowest activation energy, the quality parameter of *Rujak cingur* instant sauce is assessed from the Total Plate Count parameter. The shelf life of *Rujak cingur* instant sauce based on the Arrhenius equation on the maximum limit of total microorganism contamination is 89 days at 25°C. However, based on panellists' rejection, the shelf life is 113 days at 25°C.

Acknowledgments

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