Shelflife prediction of biscuits prepared from modified suweg (Amorphophallus campanulatus B) flour using Arrhenius model

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Abstract. Shelf life is very crucial information mentioned such as in food packages due to safety of food products when they reach their valid period to consume. The objectives of this study were to know shelf life of biscuit made of wheat flour and modified cassava flour with and without modified suweg flour and to know suitable packages for Shelf life prediction was based on moisture content and peroxide number in different packages: aluminium foil and metalized. This study showed that suitable packages for modified suweg biscuit were metalized package. According to the study, prediction of shelf life using the Arrhenius method with different shelf temperature resulted in modified suweg biscuit and blank biscuit (without modified flour suweg). To conclude, shelf life was determined by peroxide value for modified suweg biscuit in the temperature of 15 °C, 30 °C and 45 °C with metalized package resulting in 217, 172, and 137 days, respectively. While shelf life study of blank biscuit was done at 15 °C, 30 °C and 45 °C in a metalized package and resulted in 333, 250, and 192 days of shelf life, respectively.

Keywords: Arrhenius, biscuit, modified suweg flour, shelf life

1. Introduction

Biscuit is a dried food product made by baking the dough made of wheat flour or with its substitutes, oil or fat with or without other additional ingredients and allowed food materials [1]. Biscuit is a snack that is favored by all. Therefore, there are many kinds of biscuit in the market. In addition, there are countless modifications in the making. Basically, biscuit is made of wheat flour, but during its development, there have been many modifications by adding or replacing it with other ingredients, such as tapioca starch, modified cassava flour, sweet potato flour, and suweg flour.

Shelf life is the time interval between the time of production and consumption in which the product is in a satisfactory condition based on the characteristics of appearance, taste, aroma, texture, and nutritional value [2]. Shelf life is one type of information that food manufacturers must mention in food packages. Mentioning shelf life in the packages is very crucial information for the safety of food products and to avoid their consumption when they reach their valid period [3]. Syarief [4] stated that...
food quality changes mainly could be determined by the changes of quality, so determining the shelf life of a product needed measurement towards the product quality attributes.

Valid period or shelf life of biscuit can be determined by using a conventional method of *Extended Storage Studies* (ESS) and a non-conventional method of *Accelerate Storage Studies* (ASS), which is an accelerated method of *Accelerated Shelf Life Testing* (ASLT). The conventional method takes a long time and is costly since shelf life prediction is done in daily condition. It is different from the accelerated method that needs a relatively shorter period [5].

Suweg is a wild plant and grows well in places that are humid and away from sunshine [6]. Suweg has a prospect for potato flour or tapioca starch. Suweg has low amylose (24.5%) and high amylopectin (75.5%) [7]. According to [8], suweg flour has several advantages, i.e., high fiber and high protein – 13.71% and 7.20%, respectively, with low fat (0.28%). In addition, the glycemic index of suweg flour is relatively low. The study by Ekawati [9] describes that heat treatment towards suweg flour shows a significant effect towards *swelling power*, water absorption index (WAI), water solubility index (WSI), and water holding capacity (WHC). One type of biscuit that is being developed now is biscuit which was prepared for modified suweg flour, wheat flour, and mocaf. The objectives of this study were to determine the shelf life of biscuits made of modified suweg flour, wheat flour, and mocaf, and to know suitable packages for biscuit products.

2. **Materials and Methods**

2.1. **Materials and Equipment**

The materials used in this study were ingredients for making biscuit, and the materials to analyze. The ingredients for making biscuit were *autoclaving-cooling cycles* modified suweg flour, wheat flour, modified cassava flour, egg yolks, margarine, baking powder, powdered sugar (sorbitol), and chocolate powder.

The materials used for analysis are as follow: aquadest, KI, starch indicator, Na$_2$S$_2$O$_4$ 0.05 N, NaCl 0.85%, *Plate Count Agar* (PCA), N-hexane, selenium mixture, high concentration of H$_2$SO$_4$, NaOH 30%, HCl 0.01 N, boric acid, PP indicator, mixed indicator, H$_2$SO$_4$ 1.25 %, NaOH 3.25 %, acetic acid, alcohol 95%, and chloroform.

The equipment used in the study were a gas cooker, a kettle, a spatula, a digital scale, a mixer, cups, an excicator, an oven, 250 mL Erlenmeyer, 50mL buret, 1 mL pipette, Pasteur pipette, Petri dish, an incubator, aluminium foil, and metalized film.

2.2. **The process of Making Modified Suweg Flour**

The making of modified suweg flour used *autoclaving-cooling cycle* method. Suweg flour was mixed with 16% of water to make a suspension. The suspension was made into gelatin at the temperature of 70-85 °C. Then, it was heated in an autoclave at a temperature of 121 °C for 41 minutes. After that, it was cooled down in room temperature for 4-5 hours. Then it was put in the freezer of 4 °C for 12-16 hours. Then, it was dried in the drying cabinet until the water level reached 12%. Finally, it was milled and shifted through 70 mesh screens [10].

2.3. **The process of Making Biscuit**

The first step was to scale the main ingredients and other materials based on a predefined formula. The first mixing was to mix wheat flour, margarine, chocolate powder, and yolks by using a mixer until it created homogeneous cream. The next step was to mix modified suweg flour, wheat flour, modified cassava flour, milk, and baking powder. Then, the dough was molded into similar shape and size for the best baking result. The baking was done at around 120 °C for 45 minutes.

2.4. **Method**

*Arrhenius* model was used to determine the shelf life of biscuit prepared with and without modified suweg flour. The steps to determine shelf life using the *Arrhenius* model included determining valid period criteria (water level and peroxide value), determining types of packaging (metallized film dan aluminium foil), determining the temperature for the testing (15 °C, 30 °C dan 45 °C), predicting the time and frequency of sampling, plotting data according to reaction order, analysing according to
preservation temperature, and analysing shelf life prediction according to the lowest tolerable quality decrease [11].

2.5. Shelf Life Prediction

Arrhenius equation for shelf life prediction is as follow:

\[ k = k_0 \cdot A e^{-\frac{E_a}{RT}} \]

Where: 
- \( k \): the rate constant; 
- \( T \): the absolute temperature (in Kelvin); 
- \( A \): the pre-exponential factor; 
- \( E_a \): the activation energy for the reaction; 
- \( R \): the universal gas constant

Shelf life was calculated by kinetic reaction equation according to predefined reaction order, whether it followed ordo 0 or ordo 1. Shelf life prediction using the equation for ordo 0 is as follow:

\[ t = \frac{(A_t - A_0)}{k} \]

And for ordo 1 is as follow:

\[ t = \frac{(\ln(\frac{A_0}{A_t}))}{k} \]

Where: 
- \( t \): predicted shelf life of product; 
- \( A_t \): end product quality; 
- \( A_0 \): initial product quality; 
- \( k \): constant

3. Results and Discussion

3.1. Chemical Properties of Suweg Biscuit

Chemical properties of suweg biscuit are presented in Table 1. Suweg biscuit has a moisture content of 4.89% and protein content 5.55 %, which complied to the national standard for biscuit (SNI 2973-2011) with a maximum moisture content of 5.55 % and minimum protein content 5 %. The ash content in suweg biscuit is 2.73 %. According to [12], ash content showed the total of minerals in a food. Mineral and an inorganic salt in a small amount of ash are declared as food residue after the combustion process into carbon-free. Table 1 below shows the requirements of biscuit quality according to SNI 2973-2011 [1].

| No | Parameter (b/h) | Unit | Quality Requirements |
|----|----------------|------|----------------------|
| 1. | Moisture content | %    | Max 5                |
| 2. | Protein (N x 6.25 ) | %    | Min. 5               |
| 3. | Free fatty acids | %    | Max 1                |

Fat content, carbohydrate and dietary fiber content of suweg biscuit are 34.65 %, 51.05 % and 15.77 %. Carbohydrate, fat, and protein are very important to the formation of the mixture, which will affect the texture of the food produced [13]. Suweg biscuit has a starch content 36.59 %. Starch is composed of two main fractions of amylose and amylopectin [14].

| Parameter                          | Value (%) |
|------------------------------------|-----------|
| Moisture content                   | 4.89      |
| Ash content                        | 2.73      |
| Protein content                    | 5.55      |
| Fat content                        | 34.65     |
| Carbohydrate content               | 51.01     |
| Dietary fiber content              | 15.77     |
| Starch content                     | 36.59     |

3.2. Moisture Content

Moisture content is very important in determining the shelf life of a food product, especially biscuits because this factor will affect the physicochemical properties, chemical changes, and microbiological
damage [15]. Biscuit is a type of food that goes through baking process, so it is hygroscopic. This makes biscuit easily absorb moist from its surroundings until the balance between moisture and its holding water capacity is reached. This is assumed to increase biscuit moisture content [16].

The result of moisture content analysis of modified suweg biscuit and the blank (biscuit without modified suweg flour) in the aluminium foil and metalized can be seen in Table 3 and Table 4.

| Table 3. Value of moisture content of sample biscuits and the blanks on the aluminium foil packaging |
|-------------|----------------|----------------|----------------|----------------|----------------|----------------|
|             | Moisture Content (%) |              |              |              |              |              |
|             | 15 °C | 30 °C | 45 °C |              |              |              |
| **Treatment** | 4.89 | 4.99 | 4.89 | 4.99 | 4.89 | 4.99 |
| **Blank**    | 7.18 | 7.18 | 4.54 | 4.94 | 3.38 | 9.76 |
| **Biscuit**  | 11.32| 11.32| 6.13 | 6.13 | 5.47 | 5.47 |
| **Blank**    | 6.84 | 6.84 | 8.37 | 8.37 | 9.56 | 9.56 |
| **Biscuit**  | 4.26 | 4.26 | 3.42 | 10.97| 3.77 | 5.15 |
| **Blank**    | 5.49 | 5.49 | 4.59 | 9.78 | 6.55 | 4.43 |
| **Biscuit**  | 5.78 | 5.78 | 6.95 | 5.31 | 5.31 | 4.85 |
| **Blank**    | 6.63 | 6.63 | 10.8 | 6.65 | 6.65 | 3.24 |

| Table 4. Value of moisture content of sample biscuit and blanks on the metalized packaging |
|-------------|----------------|----------------|----------------|----------------|----------------|----------------|
|             | Moisture Content (%) |              |              |              |              |              |
|             | 15 °C | 30 °C | 45 °C |              |              |              |
| **Treatment** | 4.89 | 4.99 | 4.89 | 4.99 | 4.89 | 4.99 |
| **Blank**    | 4.17 | 6.46 | 5.87 | 5.32 | 3.51 | 9.78 |
| **Biscuit**  | 3.97 | 9.39 | 3.39 | 6.67 | 3.65 | 4.34 |
| **Blank**    | 5.69 | 5.36 | 5.38 | 11.41| 3.58 | 7.2 |
| **Biscuit**  | 4.18 | 5.2 | 4.38 | 2.86 | 4.45 | 10.12 |
| **Blank**    | 2.86 | 6.7 | 5.35 | 5.5 | 4.65 | 3.75 |
| **Biscuit**  | 3.6 | 5.67 | 5.53 | 12.07| 4.89 | 8.4 |
| **Blank**    | 5.19 | 7.6 | 5.9 | 8.2 | 4.8 | 8.01 |

| Table 5. Selection of ordo for sample of moisture content of aluminium foil packaging |
|----------------|----------------|----------------|-------------|-------------|-------------|
| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
| 15 | -0.034x + 4.912 | -0.004x + 1.495 | 0.394 | 0.103 |
| 30 | -0.016x + 5.244 | 0.095x + 1.428 | 0.081 | 0.226 |
| 45 | 0.011x + 4.625 | 0.009x + 1.344 | 0.028 | 0.404 |

| Table 6. Selection of ordo for sample of moisture content of metalized packaging |
|----------------|----------------|----------------|-------------|-------------|-------------|
| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
| 15 | -0.009x + 4.551 | -0.002x + 1.509 | 0.032 | 0.046 |
| 30 | 0.019x + 4.579 | 0.004x + 1.507 | 0.165 | 0.147 |
| 45 | 0.017x + 3.88 | 0.004x + 1.346 | 0.230 | 0.236 |

| Table 7. Selection of ordo for blanks of moisture content of aluminium foil packaging |
|----------------|----------------|----------------|-------------|-------------|-------------|
| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
| 15 | -0.036x + 7.763 | -0.006x + 2.019 | 0.066 | 0.090 |
| 30 | 0.101x + 5.188 | 0.014x + 1.651 | 0.540 | 0.595 |
| 45 | -0.075x + 7.810 | -0.013x + 2.044 | 0.290 | 0.363 |

The R² value in moisture content of all temperatures and packages (Table 5 and Table 6) had a lower value, since the result of the moisture content analysis was fluctuating. In addition, the R² value
shows that the data is not linear, so it is considered inaccurate. While selecting order for determining shelf life was seen from the most linear or accurate value from the second order. For order 0, the $R^2$ value was taken from the original data result, whereas for order 1, the value was taken from the original data that was already changed into form. After that, the $R^2$ value was compared between ordo 0 and ordo 1, to see the $R^2$ value that was higher or more linear. The $R^2$ value that was higher or more linear in the chosen order was considered as a more accurate value. From Table 5 and 6, it can be seen that the correlation coefficient of order 1 is higher than correlation coefficient of ordo 0 ($R^2$ ord 1 > $R^2$ ord 0). Therefore, the water level rate of decline follows the reaction of ordo 1.

### Table 8. Selection of ordo for blanks of moisture content of metalized packaging

| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | $R^2$ Ordo 0 | $R^2$ Ordo 1 |
|------------------|-------------------------------|-----------------------------|--------------|--------------|
| 15               | $-0.036x + 7.763$             | $-0.006x + 2.019$           | 0.066        | 0.090        |
| 30               | $1.011x + 5.188$              | $0.014x + 1.651$            | 0.540        | 0.595        |
| 45               | $-0.075x + 7.810$             | $-0.013x + 2.044$           | 0.290        | 0.363        |

The calculation referring to the critical level of SNI value resulted in constant of quality decline rate ($k$) of the moisture content of modified suweg flour and blank biscuit in each of the packages, based on Arrhenius approach, which is as following Table 9.

Shelf life of the tested biscuit was longer than that blank biscuit because the tested biscuit absorbed less water than the blank biscuit. When they were compared, the second package type of biscuit that used metalized package had a longer shelf life than the one with the aluminium foil. This was probably due to the difference in the value of WVTR (Water Vapor Transmission Rate) in both packages. The lower the value of WVTR, the lower water vapor transmission into the packages.

Shelf life of biscuit with the moisture content parameter had a much shorter valid period than the shelf life with the water parameter. This was because the original quality of both biscuits was already close to the SNI maximum value of 5%. When it was compared with Garut starch cookies biscuit, Tahudi (2012) stated that the shelf life based on critical moisture content using metalized package ranged from 24 to 157 days. While the shelf life of composite biscuit of Banten taro tuber-based on critical moisture content using metalized package ranged from 6 to 12 months [17]. [3] stated that biscuit products usually had shelf life of 12-18 months.

### Table 9. Prediction of the shelf life of sample biscuit and blanks on aluminium foil and metalized packaging

| Temperature (°C) | Product | Packaging | $E_a$ (kal/mol) | $k_0$ | Constant (k)/(Hari) | Shelf Life (Day) |
|------------------|---------|-----------|----------------|------|---------------------|------------------|
| 15               | Sample biscuit | Aluminium Foil | 4875.63 | 18.89 | 0.0037 | 6 |
| 30               | Sample biscuit | Aluminium Foil | 4775.93 | 29.19 | 0.0057 | 4 |
| 45               | Sample biscuit | Metalized | 4268,32 | 3.87 | 0.0084 | 3 |
| 15               | Sample biscuit | Metalized | 4268,32 | 3.87 | 0.0084 | 3 |
| 30               | Sample biscuit | Metalized | 4268,32 | 3.87 | 0.0084 | 3 |
| 45               | Sample biscuit | Metalized | 4268,32 | 3.87 | 0.0084 | 3 |
| 15               | Blank biscuit | Aluminium Foil | 4775.93 | 29.19 | 0.0069 | 0.29 |
| 30               | Blank biscuit | Aluminium Foil | 4775.93 | 29.19 | 0.0069 | 0.29 |
| 45               | Blank biscuit | Metalized | 4430.37 | 6.64 | 0.0042 | 0.4 |
| 15               | Blank biscuit | Metalized | 4430.37 | 6.64 | 0.0042 | 0.4 |
| 30               | Blank biscuit | Metalized | 4430.37 | 6.64 | 0.0042 | 0.4 |
| 45               | Blank biscuit | Metalized | 4430.37 | 6.64 | 0.0042 | 0.4 |

### 3.3. Peroxide Number

Fat breakdown is indicated by bad smell and rancid taste. This process is called rancidity. Rancidity process is caused by oxidation and hydrolysis both in enzymatic and non-enzymatic reactions. The parameter that can be used to determine cookies quality decrease caused by oxidative fat breakdown is by determining peroxide value [18].
The analysis result of peroxide number of modified suweg biscuit and blank (biscuit without modified suweg flour) can be seen in Table 10 and Table 11.

**Table 10.** Value of peroxide number of sample biscuits and the blanks on the aluminium foil packaging

| Days | 15 °C Treatment | 15 °C Blank | 30 °C Treatment | 30 °C Blank | 45 °C Treatment | 45 °C Blank |
|------|----------------|-------------|----------------|-------------|----------------|-------------|
| 0    | 0              | 0           | 0              | 0           | 0              | 0           |
| 7    | 0              | 0           | 0              | 0           | 0              | 0           |
| 14   | 1.37           | 0.59        | 0.6            | 0.88        | 0.9            |             |
| 21   | 0              | 0.22        | 0.89           | 0           | 0              | 0           |
| 28   | 1.62           | 0.79        | 0              | 1.04        | 0.24           |             |
| 35   | 1.35           | 1.95        | 2.69           | 1.96        | 1.93           | 1.47        |
| 42   | 2.06           | 0.55        | 2.09           | 2.67        | 1.46           | 1.72        |
| 49   | 2.11           | 3.36        | 4.34           | 5.77        | 3.76           | 4.99        |

**Table 11.** Value of peroxide number of sample biscuits and the blanks on the metalized packaging

| Days | 15 °C Treatment | 15 °C Blank | 30 °C Treatment | 30 °C Blank | 45 °C Treatment | 45 °C Blank |
|------|----------------|-------------|----------------|-------------|----------------|-------------|
| 0    | 0              | 0           | 0              | 0           | 0              | 0           |
| 7    | 0              | 0           | 0              | 0           | 0              | 0           |
| 14   | 0.87           | 1.18        | 2.41           | 0.15        | 1.86           | 2           |
| 21   | 0.98           | 0           | 0.9            | 0           | 0              | 0           |
| 28   | 0.67           | 0           | 0.36           | 1.58        | 0.48           |             |
| 35   | 1.45           | 4.45        | 1.95           | 0.43        | 1.06           | 0           |
| 42   | 2.06           | 0           | 0.86           | 1.49        | 2.41           | 1.55        |
| 49   | 1.95           | 1.32        | 5.31           | 1.83        | 4.17           | 4.36        |

According to the test of peroxide number, it shows fluctuating value in all types of biscuit in both packages. However, during preservation, peroxide number breakdown was still acceptable because it was not higher than 10 mgEq/kg, whereas that is standard value stated in SNI 01-2347-1991.

In the tested biscuit with aluminium foil package, the highest value only reached 4.34 mgEq/Kg at the temperature of 30 °C, while at the temperature of 15 °C and 45 °C, it reached 2.11 and 3.76 mgEq/Kg. In the blank biscuit with the same package, the highest value reached 5.77 mgEq/kg, similar to the one at a temperature of 30 °C. Whereas the one at a temperature of 15 °C and 45 °C only reached 3 and 4.99 mgEq/Kg.

In the tested biscuit with metalized package, the highest value reached 5.31 mgEq/Kg at the temperature of 30 °C, while the one at the temperature of 15 °C and 45 °C only reached 2.06 and 4.17 mgEq/Kg. In the blank biscuit with the same package, the highest value reached 4.45 mgEq/kg, similar to the one at a temperature of 30 °C. While the value at a temperature of 30 °C and 45°C only reached 1.83 and 4.36 mgEq/Kg.

**Table 12.** Selection of ordo for sample of peroxide number of aluminium foil packaging

| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
|-----------------|------------------------------|------------------------------|-----------|-----------|
| 15              | 0.064x - 0.441               | 0.023x - 0.281               | 0.735     | 0.642     |
| 30              | 0.007x + 1.059               | 0.004x + 0.286               | 0.906     | 0.013     |
| 45              | 0.041x + 0.055               | 0.013x - 0.002               | 0.584     | 0.528     |

The peroxide number of cookies shows an increase and a decrease, and probably it was caused by the fast oxidation reaction period influenced by humidity, air, oxygen, and light, as stated [18] in his study that oxidation level would increase adjacent to oxidation process until it reached its peak, and
then it would decrease. This decrease was degradation of peroxide level that would be discussed. Fatty acids would be dissolved along with hydroperoxide conversion into aldehyde and ketone, and free fatty acids. The oxidation result would change smell and taste. From Table 12 and Table 13, it can be seen that correlation coefficient of ordo 0 is higher than correlation coefficient of ordo 1 (R2 ordo 0 > R2 ordo 1). Therefore, the decrease in water level followed the reaction of ordo 0.

### Table 13. Selection of ordo for sample of peroxide number of metalized packaging

| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
|------------------|------------------------------|------------------------------|-----------|-----------|
| 15               | 0.043x - 0.06                | 0.016x - 0.243               | 0.880     | 0.479     |
| 30               | 0.066x - 0.204               | 0.017x - 0.063               | 0.397     | 0.218     |
| 45               | 0.068x - 0.299               | 0.022x - 0.118               | 0.651     | 0.535     |

### Table 14. Selection of ordo for blanks of peroxide number of aluminium foil packaging

| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
|------------------|------------------------------|------------------------------|-----------|-----------|
| 15               | 0.048x - 0.295               | 0.016x - 0.537               | 0.613     | 0.121     |
| 30               | 0.093x - 1.034               | 0.032x - 0.501               | 0.620     | 0.581     |
| 45               | 0.077x - 0.73                | 0.023x - 0.458               | 0.614     | 0.236     |

### Table 15. Selection of ordo for blanks of peroxide number of metalized packaging

| Temperature (°C) | Regression Equation (Ordo 0) | Regression Equation (Ordo 1) | R² Ordo 0 | R² Ordo 1 |
|------------------|------------------------------|------------------------------|-----------|-----------|
| 15               | 0.032x + 0.075               | 0.010x - 0.004               | 0.127     | 0.112     |
| 30               | 0.036x - 0.361               | 0.014x - 0.693               | 0.753     | 0.084     |
| 45               | 0.055x - 0.315               | 0.016x - 0.169               | 0.379     | 0.189     |

The calculation referring to the critical level of SNI quality resulted in constant of decline rate (k) of peroxide number of modified suweg biscuit and blank biscuit in each package, which is as follow, based on Arrhenius approach.

Based on the calculation of shelf life of peroxide value using Arrhenius approach, it can be seen that the tested biscuit had a shorter shelf life than blank biscuit in both packages. In the tested biscuit and blank biscuit, the shelf life in the metalized package was longer than the shelf life in different packages.

### Table 16. Prediction of shelf life of sample biscuit and blanks on aluminium foil and metalized packaging

| Temperature (°C) | Product      | Packaging   | Ea (kal/mol) | k₀   | Constant (k/Hari) | Shelf Life (Day) |
|------------------|--------------|-------------|--------------|------|------------------|-----------------|
| 15               | Sample biscuit | Aluminium Foil | 2223.9 | 2.49 | 0.051           | 196             |
| 30               |              |             |              |      | 0.062           | 161             |
| 45               |              |             |              |      | 0.074           | 135             |
| 15               | Blank biscuit | Aluminium Foil | 2822.9 | 6.35 | 0.058           | 172             |
| 30               |              |             |              |      | 0.073           | 137             |
| 45               |              |             |              |      | 0.073           | 137             |

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Based on the calculation of shelf life of peroxide value using Arrhenius approach, it can be seen that the tested biscuit had a shorter shelf life than blank biscuit in both packages. In the tested biscuit and blank biscuit, the shelf life in the metalized package was longer than the shelf life in different packages.

### Table 16. Prediction of shelf life of sample biscuit and blanks on aluminium foil and metalized packaging

| Temperature (°C) | Product      | Packaging   | Ea (kal/mol) | k₀   | Constant (k/Hari) | Shelf Life (Day) |
|------------------|--------------|-------------|--------------|------|------------------|-----------------|
| 15               | Sample biscuit | Aluminium Foil | 2957.1 | 9.62 | 0.055           | 182             |
| 30               |              |             |              |      | 0.071           | 141             |
| 45               |              |             |              |      | 0.089           | 112             |
| 15               | Blank biscuit | Aluminium Foil | 3254.3 | 8.97 | 0.03             | 333             |
| 30               |              |             |              |      | 0.04             | 250             |
| 45               |              |             |              |      | 0.052           | 192             |

One at the factors of oxidation causing rancidity is oxygen, so packaging significantly influences Oxygen Transmission Rate ($O_2$TR). It was assumed that metalized package had a smaller $O_2$TR value than aluminium foil package. In a study by [19], the $O_2$ TR value for aluminium foil was 0.8492-0.3199 cc/m²/24 hours.
3.4. Determining Shelf Life

Based on determining suitable packages, the metalized package was selected as a suitable package for modified suweg biscuit. This was due to a longer shelf life using metalized package than using aluminium foil package. Somethings to be aware of during the packing process are the contact time between freshly processed and the packaging environment, packaging conditions that must meet safety standards [20]. Based on determining shelf life using moisture content and peroxide number, the result was that there were several different valid periods. The shelf life chosen was based peroxide number because peroxide number demonstrated a fat breakdown in the food products. Therefore, shelf life of modified suweg biscuit ranged from 217 days to 137 days, or around 7 - 4 months. The recommended shelf life mentioned in the package is at the temperature around 30 °C, because normally biscuit is preserved in room temperature at a similar temperature, around 30 °C. Therefore, the shelf life in the package is 172 days or around 5 months.

4. Conclusion

Based on the study, the suitable package for modified suweg biscuit was metalized package. Referring to the study, determining shelf life using Arrhenius method with different temperatures concluded that the shelf lives determined from peroxide number for modified suweg biscuit at the temperatures of 15 °C, 30 °C and 45 °C using metalized package were 217 days, 172 days, and 137 days, respectively. The shelf life recommended mentioning in the package was 172 days or around 5 months.

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