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Shelf Life Prediction for Canned Gudeg using Accelerated Shelf Life Testing (ASLT) Based on Arrhenius Method

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Abstract. Gudeg is traditional food from Yogyakarta. It is consist of jackfruit, chicken, egg and coconut milk. Gudeg generally have a short shelf life. Canning or commercial sterilization is one way to extend the shelf life of gudeg. This aims of this research is to predict the shelf life of Andrawinaloka canned gudeg with Accelerated Shelf Life Test methods, Arrhenius model. Canned gudeg stored at three different temperature, there are 37, 50 and 60°C for two months. Measuring the number of Thio Barbituric Acid (TBA), as a critical aspect, were tested every 7 days. Arrhenius model approach is done with the equation order 0 and order 1. The analysis showed that the equation of order 0 can be used as an approach to estimating the shelf life of canned gudeg. The storage of Andrawinaloka canned gudeg at 30°C is predicted untill 21 months and 24 months for 25°C.

1. Introduction

Gudeg is a traditional food from Yogyakarta which is also a spesific food of this region. Gudeg is processed from young jackfruit with the addition of spices and coconut milk in a long of heating time. Based on processing method, there are two types of gudeg, wet and dry gudeg [1]. Wet gudeg obtained by cooking the young jackfruit untill the coconut milk was fully permeated (one time cooking). While the dry gudeg obtained by two times cooking, by sauteing (fried sauteed) of wet gudeg. The water content wet gudeg higher than the dry gudeg. The shelf life wet gudeg was 1-2 days and the dry gudeg 3-4 days [2].

Gudeg has fairly short shelf life. Packaging and preservation technology is needed in order to extend the shelf life and improve the economic value. Canning is a method of preserving food products in hermetic packaging, heated with commercial sterilization process and without additional preservatives.

During storage, canned gudeg changing the quality [3]. To determine the expiry date of canned gudeg, shelf life prediction needs to be done in an easy way and approaching the actual shelf life. Shelf life can be achieved by Accelerated Shelf-Life Testing (ASLT) by storing food products in the specific environment that cause rapid deterioration either in temperature or humidity. Acceleration method can be done in a shorter time with good accuracy [4]. Temperature plays a key parameter to determine the product deterioration. The higher the storage temperature, the faster the food deterioration. The relationship between the temperature at the speed of degradation products can be viewed using the Arrhenius equation.

ASLT method, Arrhenius model, widely used for predicting the shelf life of perishable food by a chemical such as fat oxidation, Maillard reaction, denaturation of proteins, etc. In general, the chemical reaction rate speed faster in higher temperatures, it means the decrease of product quality occur rapidly. The shelf life of food product may be determined by the Arrhenius models, ie: canned food, fruit juice, instant mie, frozen meat and high fat product (fat oxidation), product that contain reducing sugar and protein (browning reaction) [5].

Gudeg has high content of fat (12.74%) [3], thereby potentially damage occurs during storage. Therefore we need a predictive testing period expired canned gudeg using fat damage as a critical parameter. This study aimed to predictions shelf life of canned gudeg using thiobarbituric acid (TBA) value or rancidity test as critical parameters in Arrhenius models.

2. Material and Methods

2.1. Material canned gudeg

Canned gudeg used in this reseach from "Bu Tjitro Andrawina Loka", Laksda adisucipto street 9 Yogyakarta.

2.2. Shelf Life Prediction Test Using Arrhenius Model

Canned gudeg kept at the temperature 37, 50, and 60°C. Observations were made with three replications every 7 days. The parameters analyzed was the number of thio barbituric acid (TBA). TBA value were plotted against time of storage (days) and the linear regression equation obtained. Three equations were retrieved to the three conditions of product storage temperatures. Values ln k plotted versus 1/T (K^{-1}) and obtained the value of the intercept and the slope of the linear regression equation:

$$\ln k = \ln k0 - (Ea / R)(1/T) \quad (1)$$

From the equation obtained exponential factor k0 and the value of activation energy (Ea). The shelf life of canned gudeg calculated with an equation based order reaction kinetics.

2.3. TBA Analysis

TBA analysis following the method Tarladgis [6]. Ten grams sample added with 50 ml distilled water and mash for 2 minutes with a waring blender. Transfer quantitatively to the distillation flask while washed with 47.5 ml of distilled water. Added 2.5 ml of 4 M HCl until the pH to 1.5. Add anti-foaming agent then distilled to obtain 50 ml distillate. Pipette 5 ml of the distillate in a test tube, add 5 ml of reagent TBA, cover, mix evenly and heat for 35 minutes in boiling water. Cool the test tube with water for 10 minutes then measuring the optical density (OD) at 528 nm. TBA value is expressed as mg malonaldehyde per kg sample.

3. Result and Discussion

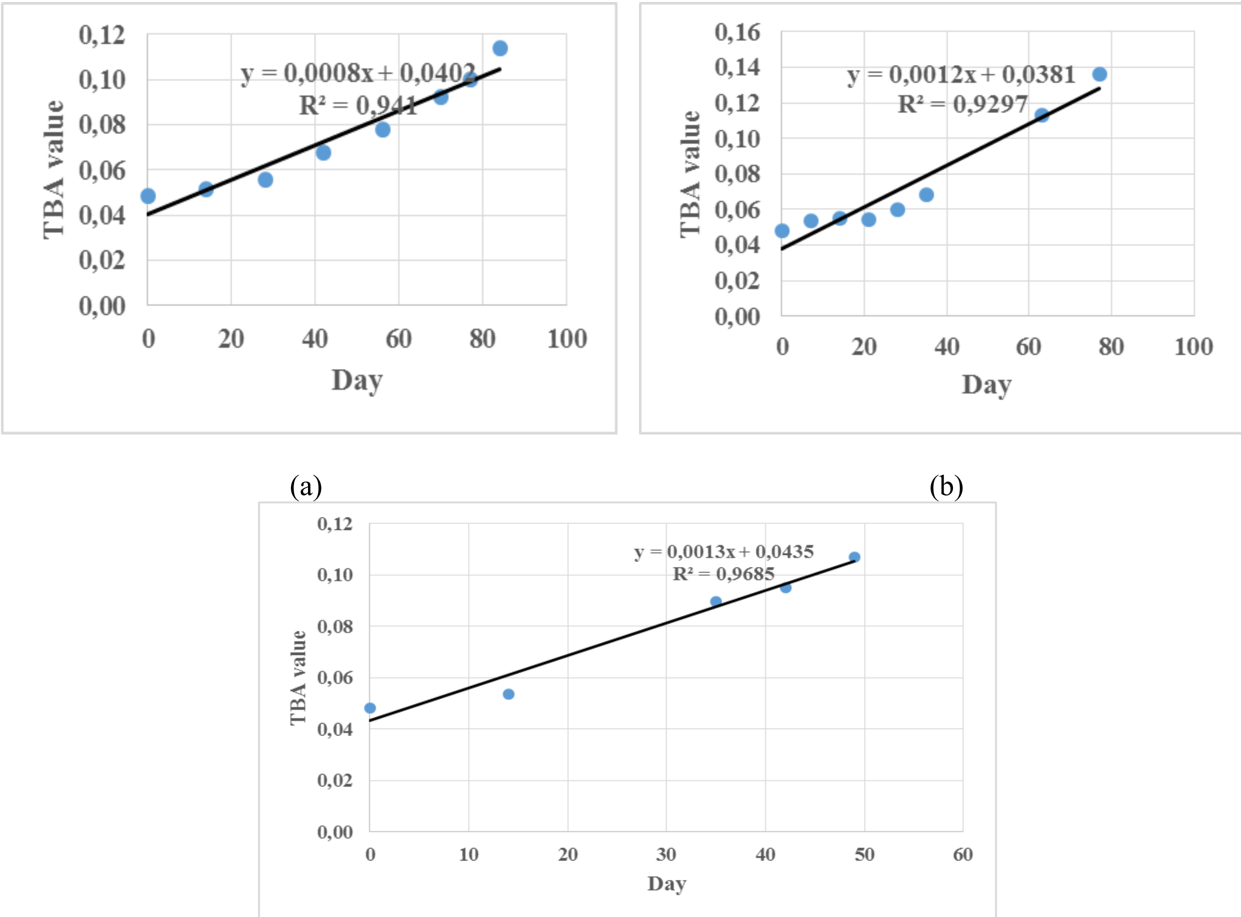
Shelf life is defined as the period of time under normal storage conditions after which the product will not be fit to eat. The shelf life of canned foods is determined by a variety of factors, related to the deteriorative reaction during storage [7].

Canned gudeg "Bu Tjitro Andrawina Loka" packaged in pull up can size 300 x 205, with 200 g in netto. Nutritional composition of canned gudeg in table 1. Fat content in canned gudeg was high, (15.2 %) if compared with protein (9.53 %) and carbohydrate (3.80 %). Therefore, fat damage is likely to occur during storage of canned gudeg.

The TBA test for malondialdehyde determination is the most frequently used method for the assessment of lipid oxidation in foods because of its sensitivity and relatively simple procedure [8]. TBA test involves the reaction between TBA and malondialdehyde produced from lipid hydroperoxide decomposition to form a pink complex with maximum absorbance at 528 nm [9].

Table 1. Nutrition composition of canned gudeg "Bu Tjitro Andrawina Loka"

Nutrition	Value
Water content	69.9 %
Ash content	1.57 %
Protein	9.53 %
Fat	15.2 %
Carbohydrate *by different*	3.80 %
Calori	190 kal/100 g



(c)

Figure 1. Plot TBA value versus time of storage canned gudeg at 37°C (a); 50°C (b); 60°C (c)

Shelf life test was done by storing the canned gudeg at incubator of 37, 50 and 60°C. TBA test was done every interval 7 days. Plot the data of TBA value versus storage time can be seen in Figure 1. The increase in TBA value during canned gudeg storage follow zero order reactions. This means that the speed of rancidity reaction of canned gudeg was constant. The longer storage, TBA number of canned gudeg was increasing [10,11,12]. The value of TBA for dried shrimp increased during storage at 37°C from 0,81 mg/kg at day 0 to 2,19 mg/kg at day 28 [11].

The TBA value of canned gudeg stored at 60°C changed more quickly than which stored at 37°C and 50°C. TBA value is widely used to measuring malonaldehyde content as a level of lipid oxidation. Malonaldehyde forms from hydroperoxides, which are initial reaction product of polyunsaturated fatty acid with oxygen [13].

The value of ln k versus 1/T (K^{-1}) from each equation Figure 1 was plotted on a graphic and obtained a linear equation ln k = -2239,2 (1/T) + 0,1281 (Figure 2). Energy of activation (Ea) to changed the value of TBA is 4.447,051 cal/mol.

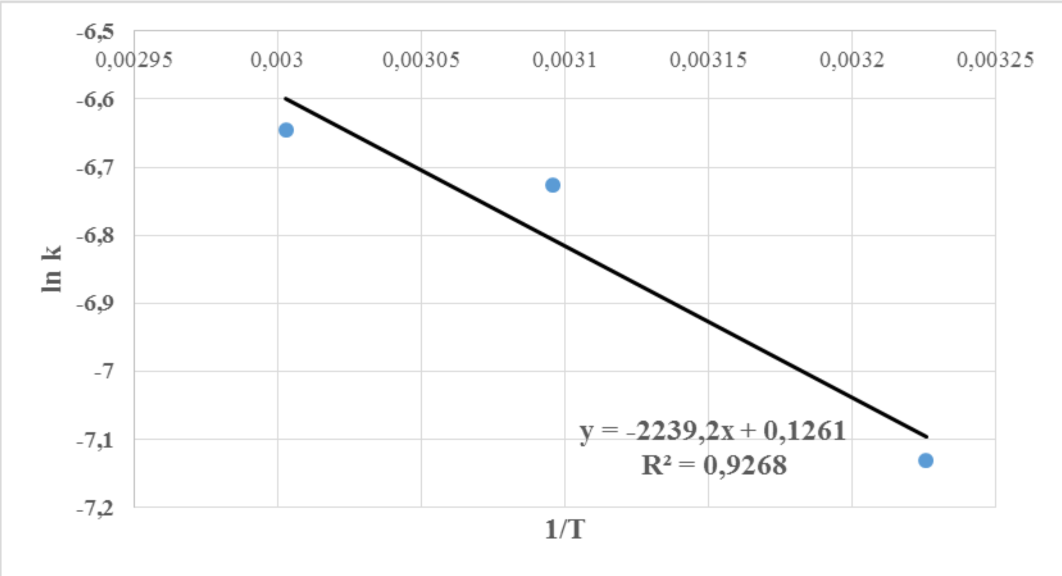


Figure 2. Plot 1/T versus ln k (Arrhenius approach)

Equation ln k = -2239,2 (1/T) + 0,1281 used to calculate the shelf life of canned gudeg at some storage temperature (table 2). The increase in storage temperature may cause a greater reaction speed. This was indicated by the increasing of deterioration constanta value (k). The greater reaction rate of deterioration, the faster the product was damaged, so the shelf life of products was getting shorter.

Table 2. The shelf life prediction of canned gudeg at the storage temperature

Storage Temperature	1/T	ln k	K	Shelf life	
				t (days)	t (months)
30°C	0.0033	-7.2620	0.0007	641.2961	21.3765
25°C	0.0034	-7.3860	0.0006	725.9537	24.1985
4°C	0.0036	-7.9557	0.0004	1283.2444	42.7748

Table 2 showed that the shelf life of canned gudeg at 30°C was 21 months, at 25°C was 24 months, and at 4°C was 42 months. Commercial sterilization of canned gudeg effectively extend the shelf life of gudeg, from 3 days to 641 days. This shelf life prediction accordance with Labuza [14] which states that the shelf life of canned fruits or canned vegetables product range from 1 to probably 3 years, depending on the composition of the product and on the quality aspect being measured. The shelf life of canned "nasi uduk" at 30°C for 9,6 months [15]. The shelf life of sterilized fermented black glutinous rice, traditional food from Mojokerto, Indonesia, at 25°C was 21 months [16].

4. Conclusion
Shelf life predictions of canned gudeg using Accelerated Shelf Life with Arrhenius approach with a number of critical parameters TBA or rancidity. The shelf life of canned gudeg at 30°C was 21.3765 months, 25°C was 24.1985 months and at 4°C was 42.7748 months.

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