IOP Conf. Series: Earth and Environmental Science **101** (2017) 012029 doi:10.1088/1755-1315/101/1/012029

Shelf life prediction of canned fried-rice using accelerated shelf life testing (ASLT) arrhenius method

M Kurniadi[1], R Bintang[2], A Kusumaningrum[1], A Nursiwi[2], A Nurhikmat[1], A Susanto[1], M Angwar[1], Triwiyono[1] and A Frediansyah[1]

[1]Research Unit for Natural Products Technology, Indonesian Institute of Sciences, Indonesia
[2]Science and Food Technology, Sebelas Maret University (UNS), Surakarta, Indonesia

Email address: hm_kur@yahoo.com

Abstract. Research on shelf-life prediction of canned fried rice using Accelerated Shelf-life Test (ASLT) of Arrhenius model has been conducted. The aim of this research to predict shelf life of canned-fried rice products. Lethality value of 121°C for 15 and 20 minutes and Total Plate count methods are used to determine time and temperatures of sterilization process.Various storage temperatures of ASLT Arrhenius method were 35, 45 and 55°C during 35days. Rancidity is one of the derivation quality of canned fried rice. In this research, sample of canned fried rice is tested using rancidity value (TBA). TBA value was used as parameter which be measured once a week periodically. The use of can for fried rice without any chemical preservative is one of the advantage of the product, additionaly the use of physicalproperties such as temperature and pressure during its process can extend the shelf life and reduce the microbial contamination. The same research has never done before for fried rice as ready to eat meal. The result showed that the optimum conditions of sterilization process were 121°C,15 minutes with total plate count number of 9,3 x 10^1 CFU/ml. Lethality value of canned fried rice at 121°C,15 minutes was 3.63 minutes. The calculated Shelf-life of canned fried rice using Accelerated Shelf-life Test (ASLT) of Arrhenius method was 10.3 months.

1. Introduction

Canned food products has been developed since several decades ago. In some countries, military ransom used special food of their own country. The United States of America (USA) has its pizza and the Phillipines has its canned rice with sausage from pork [1]. In Indonesia, rice is the main food that is consumed by many people there. More than 90% of Indonesian people consume rice as their main food [2],[3]. As the high consumption of rice in Indonesia, Indonesian people tend to process rice into other food products to avoid boredom and increase rice‟s nutrition value. One of favourite processed rice products in Indonesia is fried rice. In its serving, fried rice is processed food that must be immediately consumed, because fried rice has short shelf-life relatively. The decrease that occur on fried rice is rancidity. Beside rancidity, there are microorganisms which cause decrease and harm on a human‟s health. This is caused by chemical reactions taking place naturally, so that it will affect the taste, color, texture and nutrients in the food[4]. In the oil there are two types of main damage, which are rancidity and hydrolysis [5]. Rice-based food products are vulnerable to get contaminated by *B. cereus* that is growing and producing emetic toxins in a relatively short time on the rice storaged in room temperature [6]. Therefore, preservation is needed to extend shelf-life of canned fried rice.

In canning, sterilization process is the primary process in commercial sterile food production, especially to guarantee the security of commercial sterile food. The sterilization process in canning is heating process of the can as well as its content in many factors causing decay on food, without causing over cooking on the food [7]. In general, the canning process of food ingredients consisting of some stages, some of them are ingredient preparation, filling process, exhausting, sterilization, cooling, and storing [8]. After sterilization process, cooling process must be done immediately to prevent food over cooking and thermophilic bacteria growing. The temperature to reduce *Clostridium botulinum* number in a canned food is 121.1^{o}C for 3 minutes [9]. The indicators of optimum sterilization process is generally done by ensuring that *Clostridium botulinum* has died. Thus, other microbes which are vulnerable to heat will be automatically dead if *Clostridium botulinum* can be killed successfully.

The use of can for fried rice without any chemical preservative is one of the advantage of the product, additionaly the use of physical properties such as temperature and pressure during its process can extend the shelf life and reduce the microbial contamination. The same research has never done before for fried rice as ready to eat meal. In Indonesia, rule regarding shelf-life of food ingredients is stated in Law of Food No. 18 year 2012 regarding food and Government Regulation No.28 year 2004 regarding security, quality and nutrient of food. To determine shelf-life of canne fried rice, it needs to conduct a research regarding shelf-life prediction. One of the methods to predict shelf-life is by using *Accelerated Shelf Life Testing* (ASLT) method with Arrhenius model and food storage with extreme temperature, in which the damage on food products occur faster then the shelf life is determined based on extrapolation to storage temperature.

Based on product identification that is done, it is found that quality factor that becomes parameter of the product‟s quality decrease reaction kinetics. To find out quality decrease level, quality factor data are transformed in a plot kinetic and an appropriate kinetic parameter model will be obtained. Quality decrease process of food ingredients is stated by the following common equation [10]-[11]:

$$\frac{dQ}{dt} = k.Q^n \quad (1)$$

Q : Quality factor
t : time
k : constant rate that depends on temperature and water activity
n : degree factor or reaction order
dQ/dt : change of Q factor per time unit (positive sign if the decrease is stated in Q addition and negative if the measure one is Q decrease)

Most of all, decrease of food ingredient quality includes zero order (order 0) reaction and one order (order 1). Withevaluation of *constant rate* (k) at different three temperatures or more, Arrhenius correlation chart can be made, i.e. extrapolation with straight line of correlation between ln k and 1/T to predict kinetic reaction (k) from reactions at other temperatures [11]. Shelf-life is determined based on the most influential factor toward the product. One of the factors that is able to influence a product‟s shelf-life is temperature. Determination of shelf-life and temperature limit factor can be done by Arrhenius kinetic approach. Zero order quality decrease reaction can be stated with the following equation [12]:

$$t = \frac{(A_1 - A_0)}{K} \quad (2)$$

And for order 1 decrease reaction can be stated by the following equation:

$$t = \frac{ln\frac{A_1}{A_0}}{K} \quad (3)$$

In which:
A_1 : final score
A_0 : initial score (day-0)

K : reaction constant rate
t : shelf-life (in day, month or year)

Here we report, for the first time, the using of ASLT method for predicting shelf life of canned fried rice product

2. Materials and Methods

2.1 Sample preparation
Ingredients which are used to make fried rice are rice type IR64, garlic, onion, chilly, margarine, soy sauce, fried beef sausage, salt, fried local chicken meat and food grade cylindric can (anamel material) in size of 301 x 205 mm (Ø x h) [13]. Chemical reagents used for analysis are TBA reagent, aquades, HCl 4N, PCA media, and NaCl 0.85%.

2.2 Instruments
"Tomy"Autoclave vertical series SS-325, "Ellab" Fo meter, Thermocouple CTF 9004, "varin" seamer machine and incubator at operation temperatures.

2.3 Accelerated Shelf-life Testing (ASLT) Arrhenius Method
Kinetics observation on canned fried rice quality decrease uses *Accelerated Shelf Life Test* (ASLT) method and *Arrhenius* model. The sample is stored at 3 different temperatures, i.e. 35°C, 45°C, and 55°C. The sample parameters are observed for 35 days to get decrease rate based on rancidity testing of the product during storage as the critical parameter of the quality of canned fried rice. Next, the data which were obtained from rancidity testing were plotted in chart of correlation of time (x axis) and average sensory score on each storage temperature (y axis). The determination of shelf-life of canned fried rice is determined by the biggest R^2 (determination coefficient) value among critical parameters (TBA score) [14].

2.4 Sensory Test
Sensory test are used for knowing organoleptic level of canned fried rice to 25 untrained panelists. Organoleptic level including of colour, smell, taste, texture.

2.5 Analysis Methods
2.5.1. Total plate count
The materials used are PCA media and NaCl of 0,85%. The equipment and the materials are sterilized.About 25 g of sample was taken and mixed up using mixer machine, followed by addition of 225 ml NaCl 0,85% and homogenized. Homogenous liquor was brought to Laminar Air Flow for dilution and platting. Fresh rice sample was diluted up to 10^{-5} and canned rice up to 10^{-3}. The dilution was done by taking liquid of 1 ml and poured in to the tube containing 9 ml NaCl 0,85%. The diluted sample was platted into the petridish about of 1 ml poured on to the homogenizeed media and let stand until clotting. After clotting, petridish is put into a closed container and filled up with CO (anaerobic condition). The container is stored in incubator at 37°C for 72 hours. At the end, the number of colony was calculated manually using colony counter.

2.5.2. Target lethality (Fo)
The analysis of heat lethality value (Fo) using Thermocouple CTF 9004 which its needle installed on the wall of the can. Afterwards, canned products is sterilized with the temperature and time required. During the sterilization process, thermocouple recorded the data to be re-written in Microsoft excel and analyzed. Condition of autoclave set up at 121°C and time of 15 and 20 minutes. Fo value can be estimated with equation [15]:

$$Fo = \int_{t=0}^{t} 10^{\left[\frac{Tautoclave-121}{Z}\right]} dt \quad (4)$$

2.5.3 TBA Analysis
TBA analysis was conducted once a week during 35 days. The sample was stored at 3 different temperatures of 35°C, 45°C, 55°C (based on actual temperatures in Indonesia from distribution to products sale) during 35 days. Sample of 10 grams and aquadest 50 ml were mixed up into blender then poured into destillation flask 1000 ml with addition of aquades 47,5 ml and HCL 4 M of 2,5 ml.
Afterward destillation flask was installed on distillation apparatus and be heated until 50 ml of destilate was collected. Collected destilate then be filtered and poured into erlenmeyer followed by addition of TBA reagent of 5 ml (0,02 M thiobarbituric-acid solution in 90% of glacial acetate acid). Next step, the glass containing solution was heated on boiling water for 35 minutes, and cool down by using flowing water. Afterwards, absorbance was measured with wave length of 528 nm [16].

3. Result and Discussion

3.1. Optimum Temperature and time of Canned-fried rice Sterilization

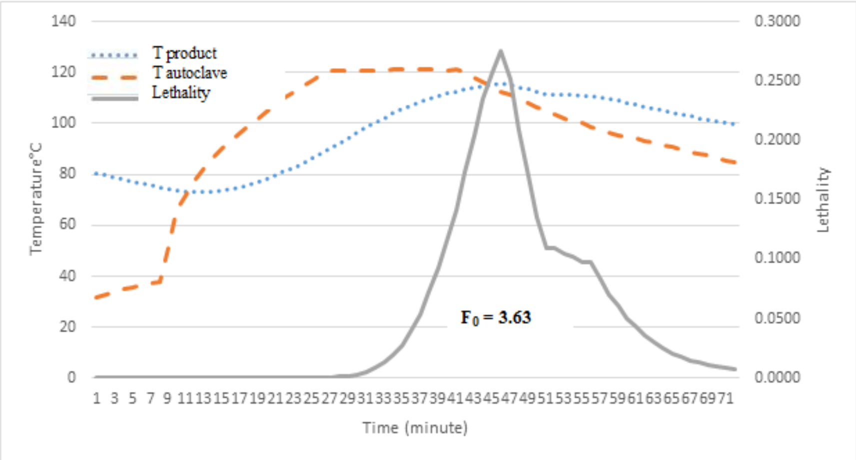

Figure 1. Heat sufficiency in the sterilization process of canned fried rice in temperature 121°C for 15 minutes

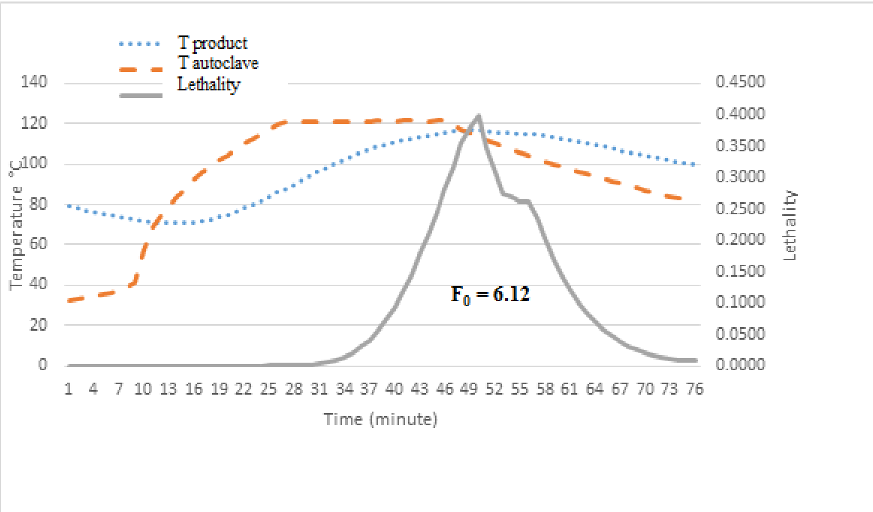

Figure 2. Heat sufficiency in the sterilization process of canned fried rice in temperature 121°C for 20 minutes

In determining optimum value of the sterilization of canned fried rice, we need to concern on Fo value in that process. Fo value is lethality equivalence of thermal processs with heating time at temperature of 250 F or 121°C. Fo value to reduce *Clostridium botulinum* by 12D is 3 minutes at minimum [17]. Microbes which can form spores has better heat resistant compared than those which cannot. Fo value that fulfill process standards is sterilization treatment at temperature of 121°C for 15 minutes that is Fo of 3.63 minutes.

Table 1. Total calculation of microbes number

Sample	Microbes Number (CFU/g)
Fresh Fried-Rice	2.3×10^4
Sterilized Fried Rice (121°C ,15 minutes)	9.3×10^1
Sterilized Fried Rice (121°C, 20 minutes)	9×10^1

Most of BPOM‟s regulations state that canned products apply maximum limit by 1 x 10 CFU/g, the products are canned corned, canned sausage, canned fish, canned fruits and canned vegetables [18]. Fried rice is not acid food therefore it safe to interact with can materials. In canned food acid, acid can be interact with Pb so it is possible for food contaminated by metal.” Gudeg ” canned that sterilized at 121°C during 20 minutes has been occured Fe (iron), S (Sulphur) and Al (alumunium) changes . No lead (Pb) has detected in the can before use as packaging . The study about metal migration during thermal process has been done in previous research[19]-[20]. This canned fried rice is safe to be consumed. It means that the process that is done during producing canned fried rice has processed well and appropriately. The can has met the requirement standard for canned food industry.

Table 2. Sensory test of canned fried rice

Sample	Colors	Favor	Taste	Texture	Overall
121°C, 20 minutes	4.32[a]	4.24 [a]	4.36 [a]	4.48 [a]	4.40 [a]
121°C,15 minutes	4.40[a]	4.40 [a]	4.44 [a]	4.52 [a]	4.48 [a]
Remarks:	Small alphabet letter for vertical comparison, and number that is followed by the same alphabet in each sample show real indifference in sig. 5%				

Sensory Score:
1 = dislike much
2 = dislike
3 = a bit like
4 = like
5 = like very much

Table 2 shows the result of organoleptic on all sensory parameters , i.e. colour , smell , taste , texture , overall are in the same *subset* . It shows that different treatments of temperature and sterilization time of canned fried rice in each sample do not show real difference among samples. It can be seen that the higher the temperature is, the longer time needed in the sterilization process, the assessment from 25 panelists will be getting decreased. It means that the panelists consider that the quality of the product decrease.

Table 3. TBA value change of canned fried rice during storage at temperature of 35, 45 and 55°C

Time (Days)	Average TBA value (mg malonaldehid/kg)		
	35°C	45°C	55°C
0	0.026	0.026	0.026
7	0.027	0.029	0.032
14	0.027	0.029	0.032
21	0.029	0.031	0.033
28	0.031	0.032	0.035
35	0.039	0.043	0.048

Rancidity limit of canned foods is 0.5 mg malonaldehid /kg. The selection of reaction order of rancidity increase on canned fried rice is done by comparing determination coefficient (R^2) in each linear regression equation at the same temperature of zero order with reaction ofone order. Reaction order with the biggest determination coefficient is the used reaction order.

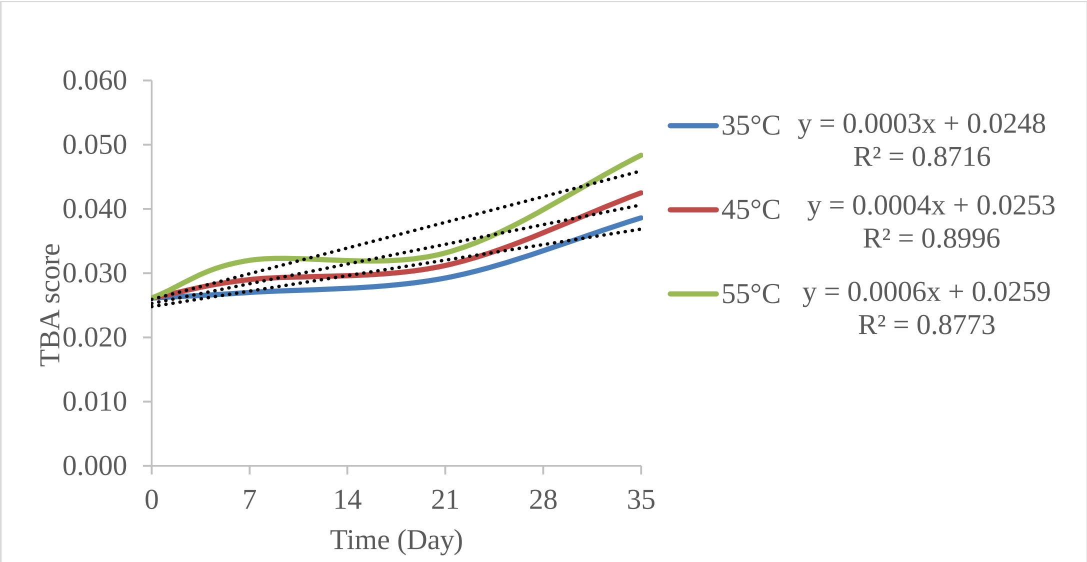

Figure 3. Chart of correlation between TBA score and time at Order 0

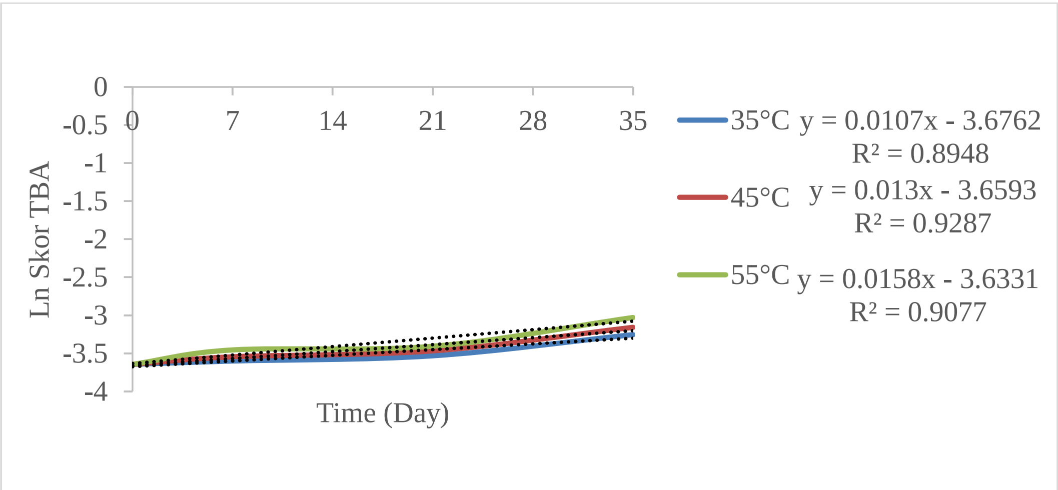

Figure 4. Chart of correlation between TBA score and time at Order 1

Table 4. K value in Order 1 of Linear regression equation

Temperature (K)	K	ln K	1/T
308	0.0107	-4.53751	0.003247
318	0.0130	-4.34281	0.003145
328	0.0158	-4.14775	0.003049

Figure 3 and Figure 4 show that R^2 value order 1 at temperature of 35, 45 and 55°C is bigger than order 0, so that order one is selected to determine Arrhenius equation. The determination of Arrhenius equation is done by making plot of ln K and 1/T (Table. 4) values in the reaction of TBA value change of canned fried rice.

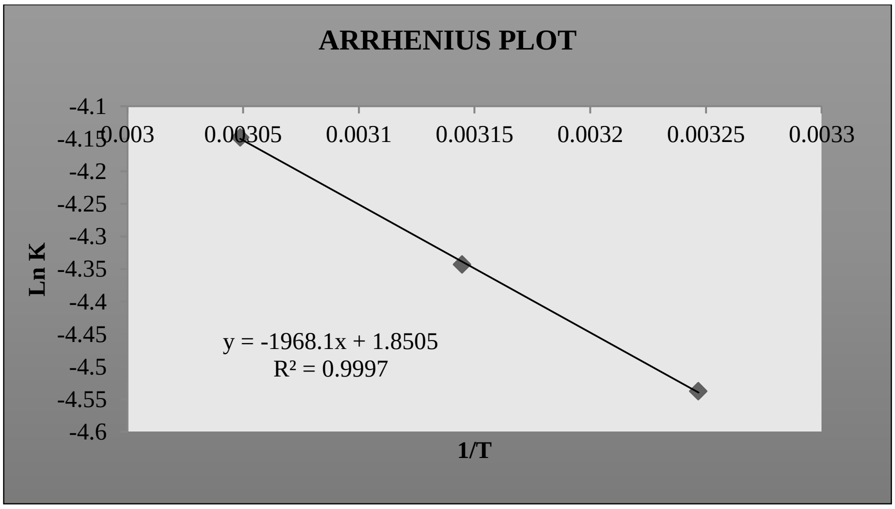

Figure 5. Arrhenius plot of TBA value of canned fried rice during storage

Linear equation from Arrhenius plot :

$y = -1968.1x + 1.8505$

For extrapolation, the storage temperature in normal condition 30 °C (303 K), Resulted :

$\ln K = -1968.1\left(\frac{1}{T}\right) + 1.8505$

$\ln K_{303K} = -4.6449$

$K_{303K} = 0.0096$

TBA critical point (A_1), resulted from previous research was 0.5 mg/kg; initial TBA (Ao) was 0.026 mg/kg, so then from equation (3) in order 1:

$$t\ (shelf - life) = \frac{\left(\ln\frac{0.5}{0.026}\right)}{0.0096}$$

$$shelf - life\ prediction\ = 307.6\ days = 10.3\ months$$

4. Conclusion

Optimum temperature and time of sterilization of canned fried rice is at 121°C for 15 minutes. The shelf-life prediction of canned fried rice by using ASLT Methods Arrhenius Model at storage temperature of 30°C is 10.3 months. We recommend to consumer to follow the guideline that has been published especially on heating step of the canned food before consumed to improve the texture and increase the appetite.

Acknowledgment
The authors would like to thank the project of Superior Research LIPI 2016 for the financial support

References

[1] Daniel 2014 *Thermal Process of canned nasi rendang : microbiology, chemical and organoleptic evaluation* Thesis (Yogyakarta: Gadjah Mada University)
[2] Biro Pusat Statistik 2008 *Statistik Indonesia: Statistical Yearbook of Indonesia* (Jakarta: Biro Pusat Statistik)
[3] Yuliawan T and Handoko I 2016 The effect of temperature rise to rice crop yield in Indonesia uses *Shierary Rice* model with geographical information system (GIS) feature *Procedia* **33** 214–220
[4] Bintoro V P, Legowo A M and Purnomoadi A 2015 Garlic antioxidant (*Allium sativum L.*) to prevent meat rancidity *Ital. Oral Surg.* **3** 137–141
[5] Macaire H, Tonfack F, Anjaneyulu B, Sri M, Karuna L, Badari R, Prasad M and Linder N 2016 Oxidative stabilization of RBD palm olein under forced storage conditions by old cameroonian green tea leaves methanolic extract *NFS* **3** 33–40
[6] Agata N, Ohta, M and Yokohama K. 2002 Production of bacillus cereus emetic toxin (*cereulide*) in various foods *Int. J. Food Microbiol.* **73** 23–27
[7] Kannan A and Sandaka P 2008 Heat transfer analysis of canned food sterilization in a still retort *J. Food Eng.* **88** 213–228
[8] Utami R 2012 Karakteristik pemanasan pada proses pengalengan gel cincau hitam (*Mesona Palustris*) Thesis (Bogor: Bogor Agricultural University)
[9] Ogbulie T E, Uzomah A and Agbugba M N 2014 Assessment of the safety of some on the shelf canned food products using PCR-based molecular technique. *Niger. Food J.* **32** 81–91
[10] Fu B and Labuza T 1997 *Shelf life testing : procedures and prediction methods for frozen foods*. (Boston: Springer) doi:https://doi.org/10.1007/978-1-4615-5975-7_19
[11] Labuza T and Riboh D 1982 Theory and application of arrhenius kinetics to the prediction of nutrient losses in food *J. food Technol.* **36** 66–74
[12] Brandão T R S and Silvaa C L M 2011 Dynamic approach for assessing food quality and safety characteristics : the case of processed foods *Ital. Oral Surg.* **1** 1015–1025
[13] Kurniadi M, Angwar M, Nurhikmat A, Susanto A, Triwiyono and Praharasti A 2015 The development of canned traditional food based military ration packaged in cans 1st *International Conference On Appropriate Technology Development* (Bandung) October 5-7, 2015 (Center for Appropriate Technology Development) pp 70-75
[14] Córdova A, Quezada C and Saavedra J 2011 A MALST method comparison over univariate kinetic modeling for determination of shelf-life in cereal snack of dried apples. *Ital. Oral Surg.* **1** 1045–1050
[15] Gonçalves E C, Minim L A, Coimbra J S R and Minim V P R 2005 Modeling sterilization process of canned foods using artificial neural networks *Chem. Eng. Process. Process Intensif.* **44** 1269–1276
[16] Devasagayam T P A, Boloor K K and Ramasarma T 2003 Methods for estimating lipid peroxidation : an analysis of merits and demerits *Indian J. Biochem. Biophys.* **40** 300–308
[17] Office of the Federal Register National Archives and Records Administration 2010 *Food and drugs: chapter 1-food and drug administration subchapter b-food for human consumption* (U.S: Government Printing Office)
[18] Badan Pengawas Obat dan Makanan Republik Indonesia 2016 Kriteria mikrobiologi dalam pangan olahan *Report Peraturan kepala badan pengawas obat dan makanan republik Indonesia (*Jakarta : Badan Pengawas Obat dan Makanan Republik Indonesia) pp 4–54
[19] Nurhikmat A, Suratmo B, Bintoro N and Sentana S 2015 The quality changes on canned gudeg ‘Bu Tjitro’ during storage *AGRITECH* **35** 353–357
[20] Dewi D C 2012 Determinasi kadar logam timbal (Pb) dalam makanan kaleng menggunakan destruksi basah dan destruksi kering *J. ALCHEMY* **2** 12-25