Sterilization of Ready to Serve Product for Special Needs of Hajj and Umrah: Skipjack Tuna in A Retort Pouch Package

Elsa Azhari[1], *Muhamad* Subroto Aliredjo[1], *Agus* Heri Purnomo[2], *Damat* Damat[3*], *Maizirwan* Mel[4,5,6], *Satriyo* Krido Wahono[7], *Suherman* Suherman[8], and *Erkata* Yandri[9]

[1]Fisheries University of Jakarta, Jl AUP Barat, Jati Padang, Jakarta 12520, Indonesia
[2]Research Center for Society and Culture, National Research and Innovation Agency, Jl. Gatot Subroto 10, Special Region of Jakarta 12710, Indonesia
[3]Department of Food Science and Technology, University of Muhammadiyah Malang, Malang 65144, East Java, Indonesia
[4]Department of Chemical Engineering and Sustainability, Kulliyyah of Engineering, International Islamic University Malaysia, Jl. Gombak, P.O. Box 10, 50728 Kuala Lumpur, Malaysia
[5]The International Institute for Halal Research and Training (INHART), International Islamic University Malaysia, 50728 Kualalumpur, Malaysia
[6]Postgraduate School, Program Study of Biology, Menara Universitas Nasional, Jl. RM. Harsono No.1, Special Region of Jakarta 12550, Indonesia
[7]Research Center for Food Technology and Processing - National Research and Innovation Agency Republic of Indonesia (PRTPP – BRIN), Special Region of Yogyakarta 55861, Indonesia
[8]Department of Chemical Engineering, Faculty of Engineering, Diponegoro University, Jl. Prof. Soedarto, SH Kampus Tembalang, Semarang 50275, Indonesia
[9]Graduate School of Renewable Energy, Darma Persada University, Jl. Radin Inten 2, Pondok Kelapa, Special Region of Jakarta 13450, Indonesia

Abstract: One crucial period in the provision of food for Hajj/Umrah is the time between opening the package and consuming it by the pilgrims. This study aimed to determine the sterilization time to prevent damage and maintain acceptance by consumers. The methodology of this research was sterilization with variations in retort pressure settings and raw materials: (A) 1.8 bar pressure, 100 % skipjack; (B) 1.2 bar pressure, 90 % skipjack; (C) 1.2 bar pressure, 70 % skipjack; (D) 1.8 bar pressure, 50 % skipjack. The analysis included two components. The (i) was the determination of the adequacy of sterilization time, the (ii) was the observation of quality deterioration, which was based on organoleptic and Total Plate Count. The results showed that the adequacy of sterilization for variations A, B, C, and D was: 121.5 °C for 4.8 min; 114.5 °C for 4.8 min; 115.4 °C for 5.31 min, and 124.0 °C for 13.4 min. TPC analysis, which was carried out at 0 h, 3 h, 9 h, and 12 h in a row were 4×10^0, 2×10^2, 2×10^2, and 3×10^3. In terms of consumer acceptance, sterilized products have good values, with organoleptic values ranging from 7.8 to 8.2 (scale 1 to 10).

Keywords: Deterioration, food preservation, *Katsuwonus pelamis* Linnaeus 1778, lethal rate, sterilization time

1 Introduction

The Coordinating Ministry for Economic Affairs estimates the number of Indonesian pilgrims to reach 4.34×10^6 in 2019 and is expected to reach 5.24×10^6 in 2022. The number of Indonesian Umrah pilgrims has increased every year, in 2016 reaching 699.6×10^3 pilgrims increase of 7.2 % from the previous year while in 2018 Umrah pilgrims reached 1.1×10^6 people and are predicted to increase. This can be seen from the waiting list or waiting list of prospective pilgrims recorded to date [1].

The index of satisfaction of pilgrims from Indonesia for domestic government services currently was only 84.85 in 2017 to 85.23 in 2018 [2]. Therefore, the government continues to make efforts to comfort pilgrimage and Umrah from Indonesia. Among the efforts is the coordinated plan of the Ministry of Religious Affairs and the Ministry of Marine and Fisheries (KKP), by which nutritious fish products are to be added to the Indonesian pilgrims.

* Corresponding author: damatumm@gmail.com

The problem is related to the palatability and quality maintenance of the product, especially during the product delivery periods. In line with this, the right preservation is very critical. Preservation has the function to inhibit or stop some of the activity of spoilage bacteria in the body of the fish. Food preservation techniques that can be determined and widely used are preservation with high temperatures, for example is the storage of fish products in dermatological packaging.

Basically, the thermal process in the processing and preservation of food is intended to eliminate or reduce undesirable biological activity in food ingredients, for example, enzyme and microbiological activities. It turns out that during the thermal process also occurs simultaneously damage to nutrients such as vitamins and factors that affect the quality of food ingredients such as color, texture, and taste. The existence of this fact causes the thermal process to develop into an optimization process that aims not only to extend the shelf life of food in closed containers but also as much as possible try so that the preservation process using high temperatures can maintain the nutrition of food ingredients as much as possible. Thus, optimization of the process of sterilization of canned food is needed to be able to determine the combination of temperature and time during heating that can meet food safety criteria.

The adequacy of the thermal process is very dependent on the natural conditions of the product, pH, resistant microorganisms or enzymes, product sensitivity and the type of heat application used [3]. The rate of decline in the number of microbes by heat to a safe level follows first-order or decreases logarithmically. Mathematically the decrease in the number of microbes or logarithmic cycles of microbial decline (S) is expressed by the Equation (1):

$$S = \log\left[N_o / N_t \right] \tag{1}$$

where N_t is the number of microbial populations after the thermal process t minutes and N_o is the number of initial microbes before the process is carried out. Since the understanding of the temperature distribution inside the retort is vital for optimizing the sterilization process, several studies have been published that present the results of both experimental and simulation attempts to identify the temperature distribution profiles inside the retort [4].

The adequacy of the thermal process to kill the target microbe to the desired level is expressed in F0 values. In general, the F0 value is defined as the time (usually in minutes) needed to kill the target microbes to a certain level at a certain temperature. For low-acid fishery products, the target bacteria is *Clostridium botulinum,* and where the sterilization process uses the 12D concept. In the 12D concept, a thermal process is carried to reduce microbes by 12 logarithmic cycles or F = 12D [5].

The resulting fishery products are packaged in retort plastic pouches, which are then sterilized. A retort pouch is a flexible packaging in the form of a pouch or bag that is used to package ready-to-eat food products. Retort pouch packaging has been widely used in the sterilization of products to replace cans, because the packaging of such cans is relatively expensive, causing the price of products packaged with the packaging to become expensive. The packaging is made of aluminum foil and polymer laminate materials that are resistant to the sterilization process. The expected outcome of sterilization using this kind of material is consumer satisfaction. Regarding consumer satisfaction with fishery products, satisfaction should include a number of common attributes such as stability, safety, composition, and better health effects [6]. The current state of the art in retort pouch processing has increased commercial value and can offer consumers a level of quality, safety, and convenience not realized by other means [7].

In addition to being closely related to the characteristics of the product characteristics, the more general safety and quality of the food as well as producing fishery products that can be directly prepared and have fairly good competitiveness. This is the basis that safe products with high quality, both quality and taste will provide high selling points. The purpose of this study is to determine the temperature setting and the sterilization time of skipjack fish in retort plastic pouch packages with the coldest target point reaching the sterilization temperature. The adequacy of the sterilization process can be determined through the calculation of Thermal Death Time (TDT) or F0. Biological and chemical indicator testing is also carried out for ongoing quality assurance testing of representative samples of the actual sterilized product and product testing when major changes are made in the packaging, packaging, or cargo configuration [8].

2 Materials and methods

The main ingredient used is fresh skipjack (*Katsuwonus pelamis* Linnaeus, 1758) size of 2 kg, obtained from the fish auction place. Fish preparation included washing, cleaning, and cutting under running water. Additional ingredients were then added to the cleaned and cut fish. The additional ingredients were potato and seasoning agents. Four combinations of material were prepared for experiments, namely:

A. 100 % skipjack
B. 90 % skipjack, 10 % potatoes
C. 70 % skipjack, 30 % potatoes
D. 50 % skipjack, 50 % potatoes

The packages were plastic retort pouches of 13 cm × 20 cm dimensions. These packages were of aluminum foil or nylon coating and can be sterilized up to a temperature of 135 °C packagings. The instrument used for the sterilization process is the Gonzon retort, whose specifications were: 3 500 W electric heating power and 0.66 m^3. During the experimental sterilization, the retort temperature was set at 121.1 °C; meanwhile, the pressure and the material followed four combinations:

i. Pressure of 1.8 bar, combination A
ii. Pressure of 1.2 bar, combination B
iii. Pressure of 1.2 bar, combination C
iv. Pressure of 1.8 bar, combination D

The increase in temperature during the sterilization process was monitored through the reading machine of the Data Logger brand Ellab CTF9004. A connecting cable connected this machine with the retort chamber and the coldest point of the sterilized material, which was the center of the product in the retort plastic pouch. Data reading of temperature development was processed using Microsoft Office Excel software. The calculation was done using the Improved General Method equation developed by Lewis in Praharasti [3], in Equation (2) and Equation (3):

$$L = 10^{\left\{ \left\{ T - 121.1 \right\} / 10 \right\}} \quad (2)$$

where F0 can be calculated by the Equation (3):

$$F0 = \int L dt \quad (3)$$

The calculated lethality (F0) was used to determine the value of sterilization or a reference for the sterilization process of the sterilized material. After the lethal rate was calculated using Equation (1), the F0 value was calculated using Equation (4):

$$TDT_T = \sum \left(Lvalue \right) \times \Delta t \quad (4)$$

The calculation of the sterilization value (sterilization value) was done using the Equation (5) and Equation (6):

$$TDT_T = F0 \times 10^{\left\{ \left\{ 10 - 121.1 \right\} / 10 \right\}} \quad (5)$$

$$\text{Sterilizat ion value} = \sum \left(1 / \text{TDT} \right) \times \Delta t \quad (6)$$

The unit F0 was minute while the unit of sterilization value is min^{-1}.

In addition to the determination of the sterilization adequacy, the method used in this study was the measurement of organoleptic and TPC values, which were intended to determine the deterioration of quality after the product was opened from its packaging, with a span of 0 min, 3 h, 6 h, and 9 h.

The organoleptic value measurement referred to the standard of the closest product. This was the Indonesian National Standard [*Standar Nasional Indonesia*/SNI] 2346: 2006 concerning the canning of mackerel and sardine in *Balado* sauce. Meanwhile, Total Plat Count testing was based on the SNI 2332: 2015 concerning the TPC testing on fishery products.

3 Results and discussion

3.1 Sterilization process needs

The adequacy of sterilization is associated with the F0 value, which is calculated from plots that link temperature, time, and LR (microbial mortality rate of various temperatures), which is read from the sterilization process.

The plot of the LR value and time produces a thermal death velocity curve (TDT). The F0 value is obtained from the area of the trapezoid on the TDT curve, by adding up the two sequential LR values divided by two and multiplying by Δt [9]. Based on the above approach, the following are the results of reading the sterilization process for samples A, B, C, and D. Optimization of thermal processing for minimizing nutrient loss without compromising safety was the major challenge for the food industry [10].

3.1.1 Sample A

In the sterilization of Sample A, the maximum temperature measured at the retort temperature was 121.5 °C and the product temperature was 117.4 °C. This sterilization process resulted in the temperature of the sterilization process

 https://doi.org/10.1051/e3sconf/202337400010

reaching the target temperature. In this case, the graph of temperature and time rise in the process of sterilizing sample A can be seen in Figure 1.

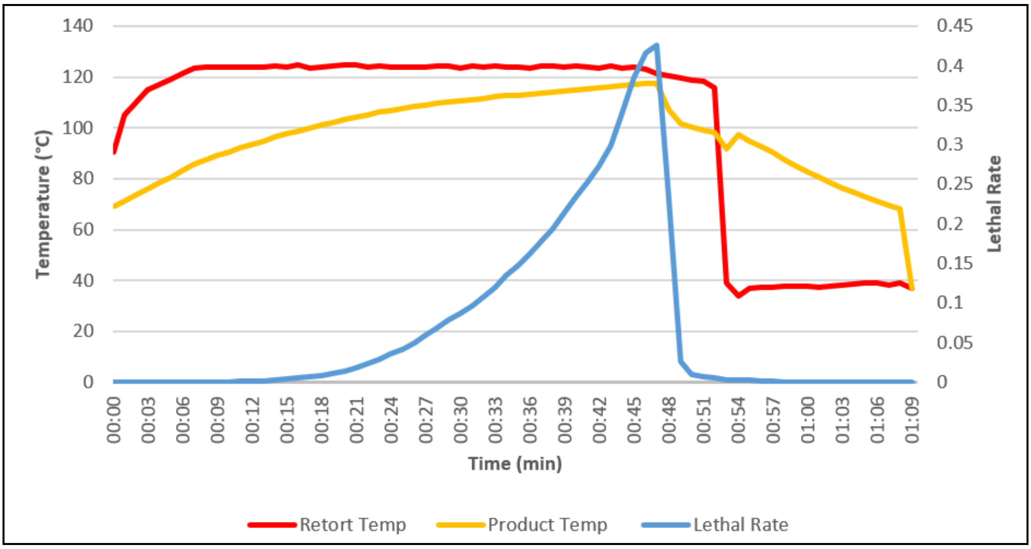

Fig. 1. Sample graph sterilization process A

Figure 1 shows that the maximum temperature is 121.5 °C. From Figure 2 it was found that the time required for sterilization (F0) is 4.84 min. Note: this value was the sum of partial F0, where partial F0 was the trapezoid area of the TDT curve per minute [3].

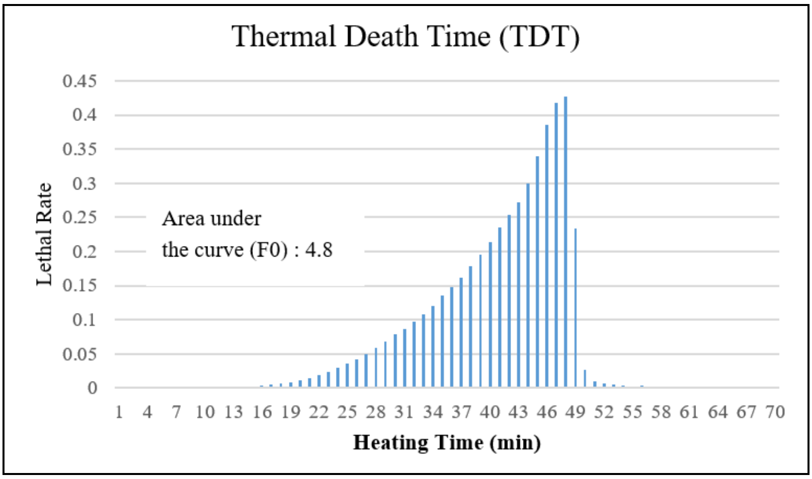

Fig. 2. Graph of thermal death time (TDT) process sample A

3.1.2 Sample B

In sterilization of sample B, the maximum temperature measured at the retort temperature was 114.5 °C and the product temperature was 113 °C. This sterilization process resulted in the temperature of the sterilization process not reaching the target temperature. Graph of temperature and time rise in the sterilization process can be seen in Figure 3.

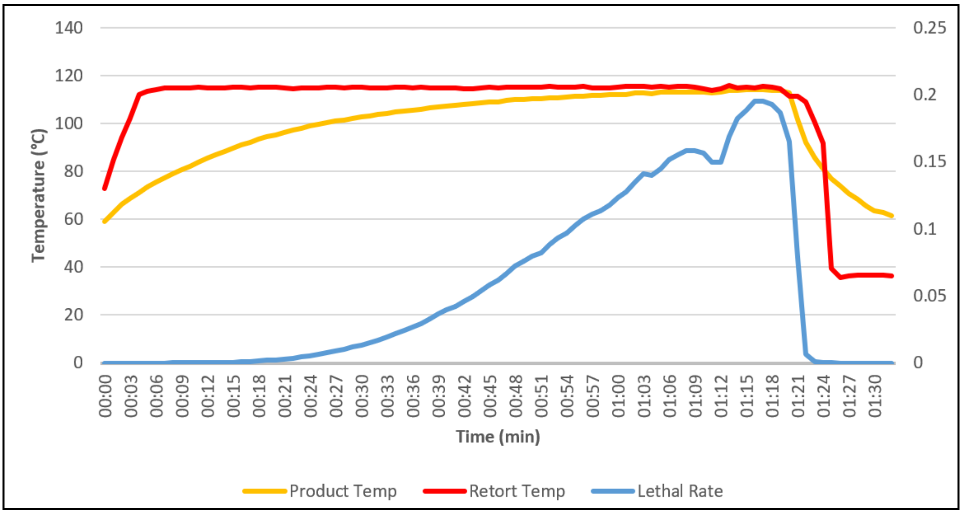

Fig. 3. Graph of the sample sterilization process B

Figure 3 shows that the maximum temperature for sterilization of sample B is 114.5 °C. The need for sterilization time can be seen in Figure 4, which was 4.75 min.

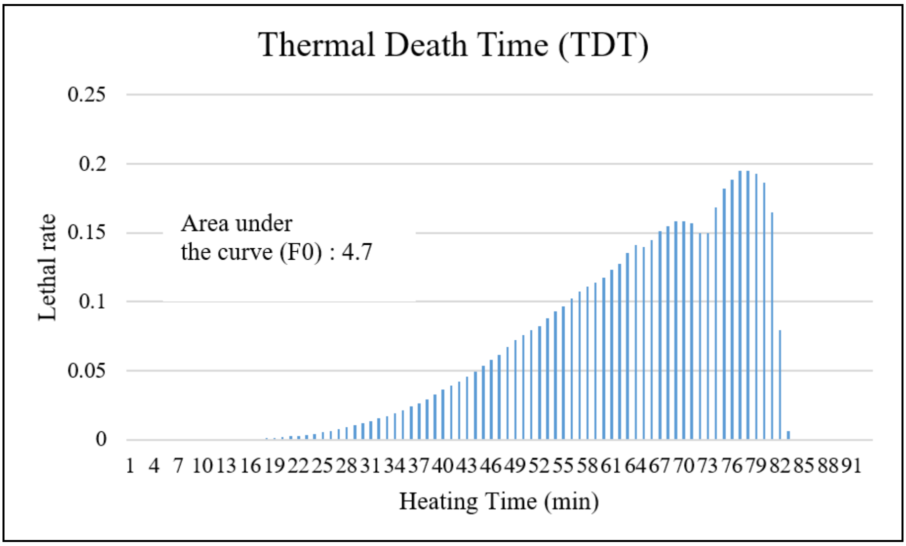

Fig. 4. Graph of thermal death time (TDT) process sample B

3.1.3 Sample C

In the sterilization of sample C, the maximum temperature measured at retort temperature was 115.4 °C and the product temperature was 114 °C. This sterilization process results in the temperature of the sterilization process not reaching the target temperature. The graph of temperature and time increase in the sterilization process can be seen in Figure 5.

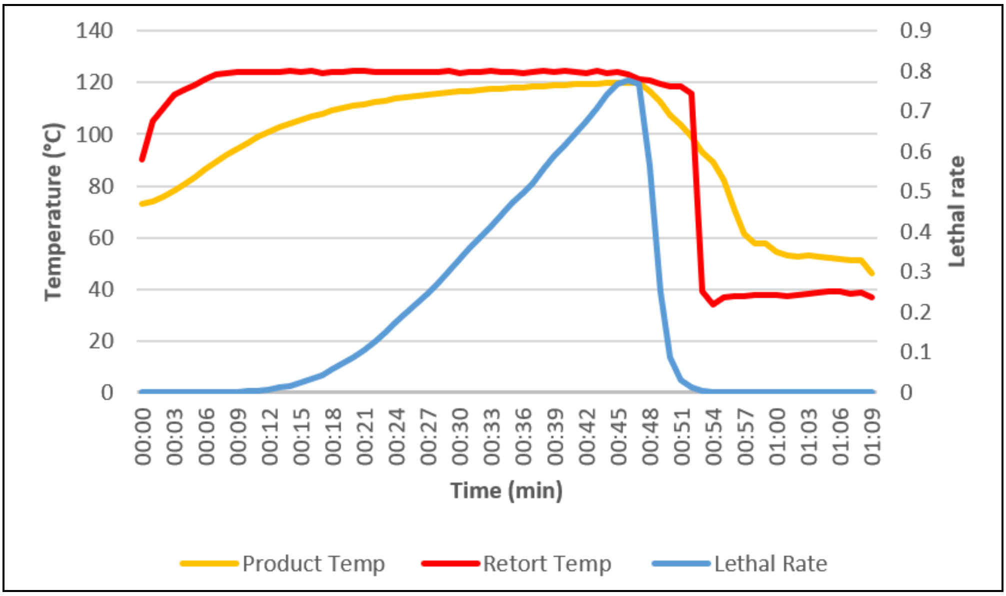

Fig. 5. Graph of sample sterilization process C

Figure 6 shows that the maximum temperature for sterilization of Sample C was 115.4 °C. The need for sterilization time can be seen in Figure 6., *ie* 5.31 min.

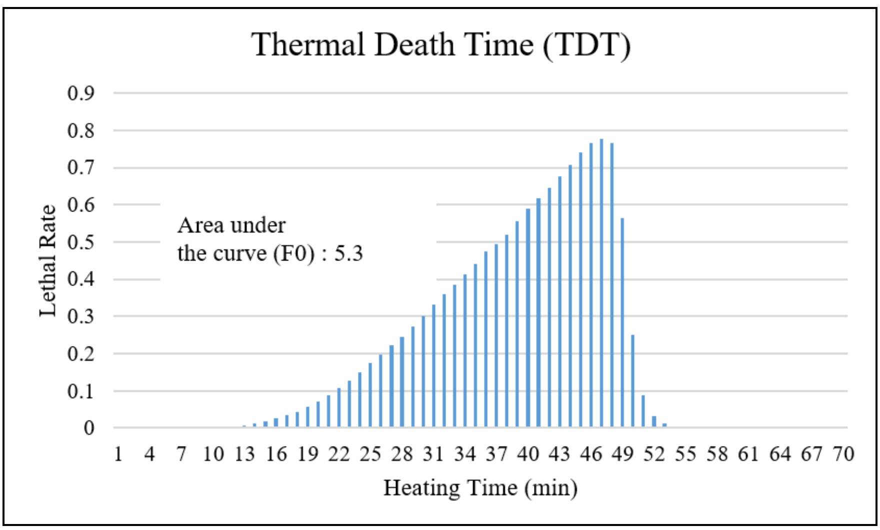

Fig. 6. Graph of thermal death time (TDT) process Sample C

3.1.4 Sample D

In sample D sterilization, the maximum temperature measured at retort temperature was 124 °C and the product temperature is 118 °C. This sterilization process resulted in the temperature of the sterilization process reaching the target temperature. Graph of temperature and time rise in the sterilization process can be seen in Figure 7.

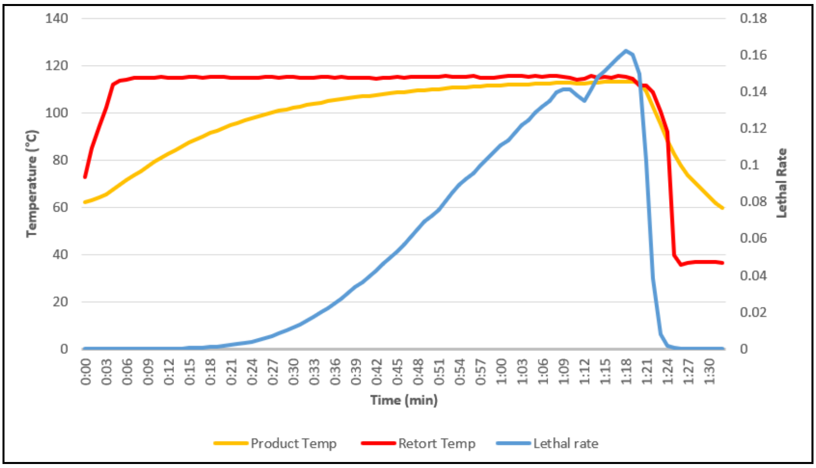

Fig. 7. Graph of sample sterilization process D

Figure 8 shows that the maximum temperature for sterilization of sample D is 124 °C. The need for sterilization time can be seen in Figure 8, which is 13.38 min.

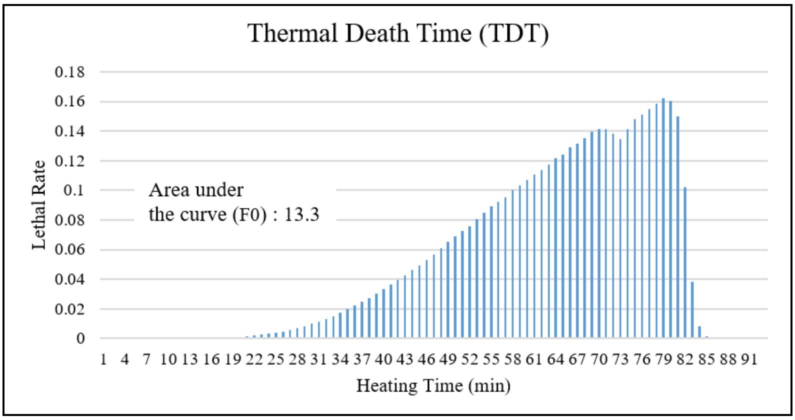

Fig. 8. Graph of thermal death time (TDT) process sample B

The results of measurements of sterilization time in samples A, B, C, and D show different time requirements. This can be linked to the type of material processed, packaging material, and its sterilization process. Using a risk-based approach, when the total outcome of controlling initial levels (H0), reducing levels (SR), and preventing an increase in levels (SI) is less than or equal to the target a food safety objective (FSO), the product is considered safe [11].

The graph of temperature rise during the sterilization process experiences a difference between the product temperature and the retort temperature it is influenced by the heat penetration process in the material. When heating or cooling the product, the increase or decrease in product temperature occurs more slowly than the increase or decrease in retort temperature. According to [12], differences in temperature rise in products and retort temperatures are influenced by the nature of heat propagation or products that are in the packaging. To overcome the limitations of non-thermal and thermal methods of food preservation, the HPTS process has been designed by combining pressure and temperature with the application of lower intensity, but with equivalent or even higher degrees of stability and safety [13].

Heating in the sterilization process is carried out at temperatures above 100 °C in enough time to kill bacterial spores. Commercially sterile foods usually have a high shelf life and durability, lasting several months to several years. This sterilization value determines the degree of destruction of microorganisms in food and relative to the concentration of microorganisms, the value of sterilization here is given by the Fo equation [14].

Determination of the time of the sterilization process (Fo) in samples A, B, C, and D have been fulfilled to destroy the target bacterium, C. *botulinum* by using the 12D concept of 2.52 min [3]. The sterilization process in each sample exceeds 2.52 min, which indicates that the process of killing spoilage bacteria is appropriate. According to [14] that the D value for C. *botulinum* is estimated at 0.21 min at 121.1 °C with a z value of 10 °C, meaning that the 12D application is equivalent to a heating time of 12 × 0.21 min = 2.52 min at a temperature of 121.1 °C which is known as the minimum lethality (Fo) process. The adequacy of the thermal process to kill target microbes to the desired level is expressed by the value of Fo [15]. No matter what type of retort system is used in a canning facility, the retort operating procedures must ensure that uniform processing temperature is achieved and maintained throughout the location of containers during the process [4].

3.2 Organoleptic testing

Organoleptic testing was carried out by 30 panelists, according to ATM (American Standards Testing Materials) quoted by Negara [16], conducting organoleptic retting tests requires a minimum of 20 untrained panelists or eight trained panelists. Therefore, to minimize errors (biases) in testing, panelists whose numbers exceed the standards are used. The measurement results can be seen in Table 1.

Table 1. Organoleptic test results of skipjack fish in retort plastic pouch packaging

Observation	**Results of the Sensory Sample**				**The score of SNI 2346: 2006**
	A	**B**	**C**	**D**	
1	8.6	8	8	7.8	
2	8	8	7.9	7.7	
3	8	8	7.9	7.7	
4	8	8	7	8	7
5	8.5	8	8	7.7	
6	8	8	8	7.8	
Average	8.2	8	7.8	7.8	

The results of sensory testing carried out showed that sample A had the highest rating score and sample D had the lowest rating score. This shows that sample A is the most popular, namely tuna fish products without the addition of potatoes is the most popular. This is influenced by the appearance, smell, taste, and consistency of the medium or *Balado* seasoning. The packing system proposed in this work constitutes a novel and promising strategy to enhance the quality of commercially canned fish products [17]. As well as the results of the assessment of the appearance, smell, taste, and texture of skipjack meat. One of the favorite tests of food products can be done by testing the aroma of a food can be assessed by the sense of smell or smell. The aroma of food determines a lot of the delicacy of the food and smell can recognize the taste of food [15]. The color of the surface of tuna fish in a retort plastic pouch is predominantly reddish in color produced from *Balado* seasonings. Determination of the quality of foodstuffs generally depends on the colors they have, colors that do not deviate from the colors that should give a distinct impression to panelists [16].

3.3 TPC testing

The issue of the quality and food safety of fishery products is a matter that must be considered and fisheries product production activities. That is because the deterioration of fish quality cannot be denied because fish is a high-perishable product (perishable) so it requires special handling [18]. One of them is to identify the quality of fishery products by conducting microbiological testing. Testing of Total Plate Count (TPC) or the number of microorganisms can be used as a parameter (benchmark) of quality in fishery products. The microbiological examination is a prerequisite for the correct diagnosis of canned products after sterilization [19]. TPC measurements are carried out by storing products without packaging with a different shelf life. TPC test results can be seen in Table 2.

Table 2. TPC test results for *balado* skipjack tuna products

Test Results	**Duration of storage (h) (colonies g^{-1})**			
	0	**3**	**6**	**9**
TPC	4×10^0	2×10^2	2×10^2	3×10^3

TPC test results showed an increase in TPC results at different times, this could be due to the sample storage containers paying less attention to sanitation and hygiene so that microbial contamination and breeding occurred. The effect on the microbial population causes denaturation of proteins, which destroys enzyme activity and enzyme-controlled metabolism in microorganisms [20]. The quality of a product is influenced by the sanitation hygiene conditions of the processing, and procurement of materials, to the final product [21].

From the measurement results of skipjack tuna, it still meets the quality requirements of SNI 2332: 2015 concerning the Testing of TPC on Fishery Products with a maximum limit of 5×10^5. The results of observations with the longest storage of products are up to 9 h after the packaging is opened with the results of 3×10^3 colonies g^{-1} so that they still meet SNI requirements. Technical methods may be resorted to keeping the product, free of pathogenic and spoilage micro-organism and their toxins, free of chemical compounds causing problems, nutritional quality is retained and extending the shelf-life of fish and fishery products [22].

4 Conclusion

The need for sterilization processes in skipjack tuna products in retort plastic pouch packaging has a different time requirement (F0). This is influenced by the characteristics of the ingredients present in the product. Pressure treatment in the sterilization process is very influential on heat propagation, the lower the pressure used, the time needed to reach the target temperature will be longer and vice versa. Organoleptic test results in sample A (100 % skipjack tuna) have the highest value and D (50 % skipjack tuna with 50 % addition of potatoes) get the lowest value. TPC test results without packaging with a different shelf life (maximum 9 h) still meet the requirements.

Thanks to the head of the Research Division for Natural Product Technology Yogyakarta and Chemistry Laboratory Fisheries, the University of Jakarta for allowing the use of facilities for research. The authors say thanks also go to hajj and umrah respondents, who had been willing to participate in organoleptic tests.

References

1. Ministry of Religious Affairs of the Republic of Indonesia., Basis data – waiting list [Data base – waiting list], Kemenag RI, Indonesia (2018) [in Bahasa Indonesia]. Available at: https://haji.kemenag.go.id/v3/basisdata/waiting-list. Accessed January 26, 2020.
2. Coordinating Ministry of Human Development and Culture of the Republic of Indonesia, Laporan Kinerja Deputi Bidang Koordinasi Pendidikan dan Agama Tahun 2018 [Perfomance Report of the Deputy of Education and Religion Coordination Division 2018], Kemenko PMK RI, Indonesia (2019) [in Bahasa Indonesia]. Available at: https://www.kemenkopmk.go.id/sites/default/files/field/ReformasiBirokrasi/deputi%204.pdf Accessed December 15 2019
3. A.S. Praharasti, E.R.N. Herawati, A. Nurhikmat, A. Susanto, and M. Angwar, *Optimasi Proses Sterilisasi Rendang Daging dengan menggunakan Kemasan Retort Pouch [Optimization of the Sterilization Process for Rendang Meat by using Retort Pouch Packaging]*, in: Proceedings of the National Seminar on synergy of food, feed and renewable energy, 21–23 October 2014, Yogyakarta, Indonesia [inBahasa Indonesia] https://www.researchgate.net/publication/322819888_Optimasi_Proses_Sterilisasi_Rendang_Daging_dengan_menggunakan_Kemasan_Retort_Pouch
4. I.M. Ismail, A. Fahmy, A. Azab, M. Abadir, and S.K. Fateen, IOSR journal of agriculture and veterinary science, **6,** 4: 26–33 (2013) https://doi.org/10.9790/2380-0642633
5. S.K. Das, and M. Das, Fundamentals and Operations in Food Process Engineering (CRC Press, USA, 2019) https://books.google.co.id/books?id=9EmMDwAAQBAJ&dq
6. F. Conte, A. Passantino, S. Longo, and E. Voslavora, Ital. J. Food Saf., **3**, 3 (2014) https://dx.doi.org/10.4081%2Fijfs.2014.1983
7. P.M. Catauro, and M.H. Perchonok, J. Food Sci., **77**, 1: S29–S39 (2012) https://doi.org/10.1111/j.1750-3841.2011.02445.x
8. S.M. ElShehawy, and Z.S. Farag, Egypt. J. Aquat. Res., **45**, 4: 389–394 (2019) https://doi.org/10.1016/j.ejar.2019.08.005
9. A.A. Vicente, and L.F. Machado, Thermal Technologies in Food Processing. In: Gliński J., Horabik J., Lipiec J. [eds] Encyclopedia of Agrophysics. Encyclopedia of Earth Sciences Series (Springer, Dordrecht, 2011) https://doi.org/10.1007/978-90-481-3585-1_172
10. C. Ravishankar, Mohan, R. Yathavamoorthi, K. Shashidhar, and T. Gopal, Journal of advances in food science & technology, 271–282 (2013) https://www.researchgate.net/publication/288422636_Retort_pouch_processing_of_fishery_products
11. N.M. Anderson, J.W. Larkin, M.B. Cole, G.E. Skinner, R.C. Whiting, L.G.M. Gorris, et al., J. Food Prot., **74**, 11: 1956–89 (2011) https://doi.org/10.4315/0362-028X.JFP-11-082
12. K. G. Raptopoulou, I. N. Pasias, N. S. Thomaidis and Ch. Proestos, *The Effects of food processing and canning technologies on the nutritional value of foods*. In: Environmental and Agricultural Research Summaries, L.T. Cacioppo [eds.]. **Volume 10**, Chapter: 78, (Nova Science Publishers, USA, 2017) https://novapublishers.com/shop/environmental-and-agricultural-research-summaries-with-biographical-sketches-volume-10/
13. S.J. Ramos, D. Millan, L. Ortiz, D. Alonso, and S.G. Torre, The International Journal of Engineering and Science, **7,** 8: 65–74 (2018) http://www.theijes.com/papers/vol7-issue8/Version-1/K0708016574.pdf
14. M.K. Heshmati, M. Shahedi, N. Hamdani, M.A. Hejazi, A.A. Motalebi, and A. Nasirpour, J. Agric. Sci. Technol., **16**, 4: 827–839 (2014) https://jast.modares.ac.ir/article-23-4165-en.pdf
15. Rouweler J. (2014). Heat process calculations according to PHAM for counduction-heated canned foods – sterilization time, heat, process value F, microbial spoilage rate and nutrient retention calculations by Q.T. Pham and C.R. Stumbo's Formula Methods.xls. Research Gate. Available at *https://doi.org/10.13140/2.1.2695.7440*, Accessed January 24, 2020.

16. J.K. Negara, A.K. Sio, Rifkhan, M. Arifin, A.Y. Oktaviana, R.R.S. Wihansah, et al., Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan **4**, 2: 286–290 (2017) [in Bahasa Indonesia] https://doi.org/10.29244/jipthp.4.2.286-290
17. R.G. Barbarosa, M. Trigo, R. Fett, and S.P. Aubourg, J. Sci. Food Agric., **98**, 9: 3462–67 (2018) https://doi.org/10.1002/jsfa.8861
18. M.N. Mailoa, A.M. Tapotubun, and T.E.A.A. Matrutty, IOP Conf. Ser. Earth Environ. Sci., **89**, 1 (2017) https://doi.org/10.1088/1755-1315/89/1/012014
19. A.D. Teklemariam, F. Tessema, and T. Abayneh, Int. J. Fish. Aquat. Stud., **3**, 2: 111–117 (2015) http://www.fisheriesjournal.com/archives/2015/vol3issue2/PartB/3-1-84.pdf
20. A.G. Al-Baali, and M. Farid, Principles Of Thermal Sterilization, In: Sterilization Of Food In Retort Pouches. Food Engineering Series (Springer, Boston, 2016) https://doi.org/10.1007/0-387-31129-7_3
21. G.C. Angela, F. Mentang, and G. Sanger, Jurnal Media Teknologi Hasil Perikanan [Journal of Fishery Products Technology Media], **3**, 2: 29–40 (2015) [in Bahasa Indonesia] https://doi.org/10.35800/mthp.3.2.2015.9219
22. U. Nwaigwe, CYTA J Food, 1-31 (2017) *https://www.researchgate.net/publication/316918904_fish_preservation_and_processing*