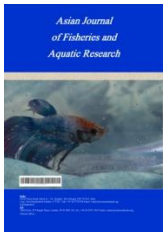

Asian Journal of Fisheries and Aquatic Research

13(4): 37-43, 2021; Article no.AJFAR.70946
ISSN: 2582-3760

A Review: Methods of Smoking for the Quality of Smoked Fish

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Authors' contributions

This work was carried out in collaboration between both authors. Author AA wrote the first draft of the manuscript. Author DYP edited the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2021/v13i430273
Editor(s):
(1) Prof. Ahmed Karmaoui, University Moulay Ismail, Morocco.
Reviewers:
(1) David Juan Ramos Huallpartupa, Jose Maria Arguedas National University, Peru.
(2) Zhisheng Zhang, Hebei Agricultural University, China.
Complete Peer review History: https://www.sdiarticle4.com/review-history/70946

Review Article

Received 13 May 2021
Accepted 26 July 2021
Published 28 July 2021

ABSTRACT

Fish that have been caught are susceptible to decay and damage which are influenced by the level of acidity, weather, processing and storage methods, and temperature during transportation. This causes losses to the fishery business. One way that can be used to reduce the damage and spoilage of fish is through smoking. The purpose of this review article is to describe various methods of fish smoking, the chemical composition of smoked fish, and the number of microbes present in smoked fish. Smoked fish still contains nutrients such as protein, lipids, fiber, amino acids, minerals, and vitamins. The growth of microbes, especially those that are pathogenic, is inhibited and even some microbes cannot grow so that smoked fish is still good for human consumption. The microbes that cannot grow include *Vibrio* spp, yeast, mold, and *Salmonella* sp. Hot smoking method uses a temperature of 30-90^{o}C, while cold smoking uses a temperature of 30-40^{o}C. The chemical composition contained in smoked fish such as water content, protein, ash content, crude fiber, amino acids, biogenic amines, minerals and phenols. While the microbiological content of smoked fish with hot and cold smoking methods has a TPC value according to smoked fish standards and is free from pathogenic microbes, fungi, yeast and molds

Keywords: Smoked fish; fish smoking method; chemical composition; microbes.

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1. INTRODUCTION

Fish is one of the perishable foodstuffs. The rate of fish spoilage depends on the handling during processing, acidity level, fish species, weather, storage mode, and temperature during transportation [1]. Fish is a perishable food. Approximately 27% of fish are caught fresh, the remaining 73% are processed by preservation methods such as salting, drying, freezing, canning, salting, and smoking [2]. Smoking can be defined as the process of penetrating volatile compounds in fish from wood burning which can produce products with specific tastes and aromas and a long shelf life. The smoking process is a combination of salting and drying processes. The smoking process can be done at any time and is not affected by the weather. Preservation processes such as conventional drying require sunlight and depend on the weather, while the smoking process does not depend on climate because the drying process can run because of the heat from the wood burning smoke.

The chemical breakdown of protein, fat, and water content contributes to the rapid spoilage of fish. Therefore, further processing is needed to extend the shelf life. One of the preparations that can be used is fish smoking. Fish smoking is one of the efforts made in the field of processing fishery products to extend the shelf life or product life (Swastawati 2007). Smoked fish has a shelf life of about 6-9 months if properly packaged and stored. Smoke drying is the most common method for smoking products. Dried smoked fish has a long shelf life and facilitates the distribution process of smoked fish to points of sale and consumers.

Smoking will produce the desired aroma and taste and can inhibit microbial growth. One of the popular methods used for fumigation is to use liquid smoke. The use of liquid smoke has several advantages, such as easy to use, the use of concentrations can be controlled easily, the resulting product is uniform, and environmentally friendly. Some areas in Indonesia have several types of smoked fish namely skipjack fufu, skipjack asar, smoked eel, sogili fufu, catfish jam, smoked catfish, and smoked milkfish. Smoked fish uses a smoking process at a temperature of 80-100ºC for 3-4 hours or at a temperature of 50-60ºC for 10-15 hours [3].

2. FISH SMOKING METHODS

The smoking method has the main working principle, namely the taste produced in fish is the result of burning wood. The wood and charcoal used to break down when burning and then smoke is formed which makes the fish smell unique and increases the taste of the fish and changes the color of the fish (Fecicilar and Genccelep 2013). The smoke produced by both wood and charcoal contains phenolic compounds, nitrites, and formaldehyde. Smoking using wood or charcoal aims to give a distinctive taste to smoked fish and aims to dry some of the fish in the form of fillets. Smoking fish is done to make smoked fish products and to extend the shelf life of the product under some conditions because it can reduce water content and inhibit bacterial growth [4].

The smoking is one way of preserving products using heat and smoke (Sahubawa and Ustadi, 2014). Smoking is one of the techniques for preserving fishery products. This is because the heat of burning wood can inhibit the growth of microorganisms, smoke components as anti microbial, and some of the smoke can coat the outer skin of fish (Wibowo, 2002). There are several factors that affect smoking, namely smoking temperature, humidity, wood type, thickness and speed of smoke flow, fish species, and treatment before smoking (Sahubawa and Ustadi, 2014). Sources of smoke can be obtained from burning wood, coconut shells, coir, sawdust, or rice husks [5] [6]. The smoking temperature used will affect the effectiveness of the sticking of the smoke and the length of time the smoking process takes. High temperatures will cause the water in the fish to evaporate quickly (Sahubawa and Ustadi, 2014). High temperatures will cause the fish meat to cook quickly and have a strong fish-like taste [7].

Smoking fish can be done by two methods of smoking, namely hot and cold smoking. Hot smoking uses temperatures above 30ºC to 90ºC. Cold fumigation uses room temperature or temperatures between 30-40ºC [8]. Smoke drying temperature, and time affect on the nutritional, and physical quality of smoked fish [9]. Smoked fish can use an agent in the form of liquid smoke. Liquid smoke is obtained from the condensation of combustion vapors containing carbon such as organic acids, phenols and other compounds [10]. Compounds in smoking raw materials such as wood and coconut shells have an effect on the quality of smoked fish such as taste, color, and anti-microbial [11].

Adawyah [12] stated that cold smoking is a smoking process using a not too high temperature, around (15-50)°C. The use of low temperatures is intended so that the fish meat does not cook quickly or the protein in the fish meat is not lost (coagulated). According to Swastawati [13], the cold smoking process takes a long time depending on the size of the fish, so cold smoking can result in smoked fish being stored longer. Drying that occurs in smoked fish meat causes the maximum moisture content of smoked fish to reach 60%. The cold smoking method according to Erkan et al. [14] can be carried out using high pressure of 220-300 MPa at a temperature of 3-25ºC for 10 minutes.

Traditional hot smoking method. According to Iwegbue et al. [15], traditional smoking with wood-burning processes will produce high levels of polycyclic aromatic hydrocarbons (PAHs), especially Benzoa pyrene (BP). These compounds are hazardous compounds that are toxic, mutagenic, and carcinogenic. According to the traditional smoking method [16]. The smoking kiln was locally improvised. Three broken blocks each of 0.3m height were used to raise the wire gauze (on which the fish were laid) to avoid direct contact with fire. Big wire gauze of mesh size 2cm was set on the fire when the fire was fully lit. The three species of fish to be smoked were placed on the gauze. A Big aluminum basin with an opening at the center was used to cover the fish species to conserve the fire. It was through the opening that the temperature of the smoking kiln (chimney) was taken daily until the three fish species were hot smoked dried. Hot smoking was done for 36 hours (this was achieved in three days at an average of 12 hours smoking per day) at an average temperature of 100ºC. Hot smoking was done with an exotic hardwood, such as Eucalyptus species, Turning of the fish species was done at the same time to maintain uniform drying\smoking at an interval of one hour (1½ hr) thirty minutes for 3days. According to Fecicilar and Genccelep (2013), hot smoking can be achieved in several phases. The smoking temperature varies between 40-100oC and the fish core temperature will rise to 85oC

Fumigation with traditional methods has been replaced by the use of liquid smoke [17] [11]. The liquid smoke does not contain the same compounds as natural smoke. The liquid smoke is safe to use because it has gone through a filtering process to remove toxins, impurities and other carcinogenic compounds. According to Martinez and Machado [18] that the phenol content in smoke can increase the distinctive taste of smoke in the product. According to Berhimpon et al. [3], the smoking procedure using liquid smoke is as follows: the raw material (fish) is separated from the bones and entrails, then the fish is filleted and soaked in 5% salt solution for 30 minutes. After soaking in a salt solution, then dried for 5-10 minutes. The dried fish were then immersed in liquid smoke with various concentrations (0.4%, 0.6%, 0.8%) for 20 minutes and dried at 70-80ºC for 4 hours. Liquid smoke application can be soaked, sprayed and smeared. According to Swastawati et al. [5], the use of liquid smoke on smoked skipjack tuna resulted in lower benzo(a)pyrene (BP) and PAH values than traditional smoking methods. The liquid smoke is an alternative smoking process that is easy to produce, use and control. Smoked fish with liquid smoke application has an edible portion of 100%.

3. CHEMICAL COMPOSITION OF SMOKED FISH

Smoking is one of the methods of preserving fishery products. Various studies on preservation by smoking have been carried out, such as the Coban and Patir [19] study on smoking Oncorhynchus mykiss with the addition of clove oil, and Ficicilar and Genccelep [20] on Rainbow Trout. The quality of smoked fish products is influenced by raw materials, smoking methods, smoking concentrations and raw materials for smoking sources [20]. Indicators in assessing the durability of smoked fish products can be seen from the values of TBA, TVB and pH as well as the value of biogenic amines consisting of histamine, putrescine, cadaverine, tyramine, and tryptamine compounds.

The quality of smoked fish can be seen from the value of protein, vitamins and minerals it contains. According to Adeyeye et al. [21], the processing of raw materials will influence on the nutritional composition of the final product. Several nutrients in the food will be lost during the processing. Amino acids, vitamins, and minerals will usually be easily decomposed due to heat so that the quality of smoked fish can be determined also from the content of amino acids, vitamins, and minerals.

4. MICROBIOLOGY OF SMOKED FISH

Traditionally processed fishery products are very susceptible to microbiological damage. Microbiological damage can be caused by

pathogenic bacteria or fungi. Damage to a product depends on the initial bacterial count, sanitation and hygiene during processing, and preservation methods and storage methods. Improper processing methods will cause the growth of Salmonella bacteria in the product [26]. According to Rukmayeni et al. [27], the smoking method using liquid smoke at a temperature of 30-60ºC can extend the shelf life of smoked fish products. This can be determined by the number of bacterial colonies during storage. Some pathogenic bacteria in smoked fish will not grow because of the heat from the smoking process. The high temperature used can damage these pathogenic bacteria as well as the presence of chemical compounds from the smoke that are useful as antimicrobials [28].

Table 1. Chemical composition of smoked fish

Parameter	Hot Smoked	Cold Smoked	References
Water content	71,01 - 73,52 %	34,56 - 52,50 %	Syam and Patang [22]; Fashagba et al. (2020)
Protein	16,11 - 52,13 %	10,16 - 21,54 %	Syam and Patang [22]; Oyeleye [16] Fashagba et al. (2020)
Lipid	0,90 - 7,60 %	30, 14 - 46,46 %	Syam and Patang [22] Oyeleye [16] Fashagba et al. (2020)
Ash	0,32 - 0,64 %	1,00 - 2,70 %	Syam and Patang [22] Oyeleye [16] Fashagba et al. (2020)
pH	6,54 - 6,57	5,00 - 5,01	Ficicilar and Genccelep [20]
Histamin	11 - 18,26 mg/kg	100 - 220 mg/kg	Ficicilar and Genccelep [20] Jorgensen et al.[23]
Putresin	3,26 - 8,90 mg/kg	4 - 15 mg/kg	Ficicilar and Genccelep [20]Jorgensen et al. [23]
Kadaverin	4,19 - 7,95 µg/g	10 - 200 µg/g	Ficicilar and Genccelep [20] Jorgensen et al.[23]
Tiramin	5,31 - 6,65 mg/kg	90 - 130 mg/kg	Ficicilar and Genccelep [20] Jorgensen et al. [23
Triptamin	14,47 - 32,17 mg/kg	< 5 mg/kg	Ficicilar and Genccelep [20]
Lysine	7,36 - 7,72 g/100 g	1,70 - 2,10 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Histidine	2,46 - 2,92 g/100 g	0,50 - 0,65 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Arginine	6,27 - 6,71 g/100 g	1,11 - 1,41 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Threonine	4,58 - 4,91 g/100 g	0,94 - 1,13 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Valine	4,52 - 4,98 g/100 g	1,04 - 1,35 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Methionine	2,49 - 2,83 g/100 g	0,61 - 0,74 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Isoleucine	3,49 - 3,95 g/100 g	1,01 - 1,13 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Leucine	7,32 - 7,80 g/100 g	1,68 - 1,80 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Phenylalanine	4,05 - 4,81 g/100 g	1,65 - 1,85 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Aspartic acid	9,59 - 9,90 g/100 g	1,87 - 2,38 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Serine	4,39 - 4,86 g/100 g	0,83 - 1,03 g/100 g	Adeyeye et al. [21]

Parameter	Hot Smoked	Cold Smoked	References
			Usydus et al. [24]
Glutamic acid	14,19 - 14,93 g/100 g	2,47 - 2,94 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Proline	4,16 - 4,68 g/100 g	0,75 - 0,84 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Glycine	7,01 - 7,61 g/100 g	0,93 - 1,19 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Alanine	6,18 - 6,71 g/100 g	1,05 - 1,38 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Cystine	0,89 - 0,98 g/100 g	0,61 - 0,74 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Tyrosine	3,17 - 3,67 g/100 g	1,65 - 1,85 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Tryptophan	4,63 - 4,83 g/100 g	0,25 - 0,31 g/100 g	Adeyeye et al. [21] Usydus et al. [24]
Ca	367 - 3412 mg/kg	84,7 - 552 mg/kg	Polak-Juszczak [25]
Fe	10,5 - 13,8 mg/kg	2,7 - 8,5 mg/kg	Polak-Juszczak [25]
Na++	0,44 - 0,88 mg/kg	2,1 - 3,18 mg/kg	Polak-Juszczak [25]
Mg	381 - 441 mg/kg	324 - 327 mg/kg	Polak-Juszczak [25]
P	2224 - 3970 mg/kg	1768 - 2265 mg/kg	Polak-Juszczak [25]
K	2162 - 2494 mg/kg	1998 - 2082 mg/kg	Polak-Juszczak [25]
Cu	0,5 - 0,7 mg/kg	0,4 - 0,5 mg/kg	Polak-Juszczak [25]
Mn	0,05 - 0,8 mg/kg	0,04 - 0,05 mg/kg	Polak-Juszczak [25]
Se	0,08 - 0,1 mg/kg	< 0,07 mg/kg	Polak-Juszczak [25]
PAH	< 0,25 ppb	< 0,25 ppb	Berhimpon et al. [3]
Phenol	0,4 - 12,6 %	0,01-0,02 %	Berhimpon et al. [3]; Usydus et al. [24]

Table 2. The number of microbes in smoked fish

Parameter	Hot Smoked	Cold Smoked	References
TPC	$4,5x10^1$ - $1,1x10^3$ Colonies/g	7,3 - 7,9 Log cfu/g	Mailoa et al. [26] Rukmayeni et al. (2020)
Salmonella	0	0	Mailoa et al. [26] Emborg et al. [29]
Lactid acid bacteria	2,5 - 4,26 Log cfu/g	2,5 - 4,6 Log cfu/g	Adeyeye et al. [21] Emborg et al. [29]
Enterobacteriaceae	0,3 - 5,27 Log cfu/g	< 6,8 Log cfu/g	Adeyeye et al. [21] Emborg et al. [29]
Gram-negative psychotropic bacteria	< 1 Log cfu/g	< 1 Log cfu/g	Adeyeye et al. [21] Jorgensen et al. [23]
Vibrio spp	0	0	Dutta et al. [30] Joffraud et al. [31]
Yeast	0	0	Dutta et al. [30 Jorgensen et al.[31]
Mold	0	0	Dutta et al. [30] Jorgensen et al. [31]

Lactid Acid Bacterial (LAB) was reported as part of natural micro flora of fish fillets. Based on [20], reported there were no significant differences were observed in LAB values of cooked and smoked samples. From the presence of LAB in the finished products, it can be concluded that these species were capable of surviving cooking and smoking. LAB seem to form the main micro flora of the vacuumpacked smoked fish at the end of the storage period generally, since they are well adapted to the conditions prevalent in these products: low pH, vacuum packaging, higher salt content, refrigerated storage. *Enterobacteriaceae* were also found to be part of

the spoilage micro flora of vacuum packaged smoked fish. In hot smoked rainbow fillets, the initial *Enterobacteriaceae* count was low as 0.3 log cfu/g and reached to 5.27 log cfu/g at the end of storage time. The initial total number of *Enterobacteriaceae* on the hot smoked rainbow trout and cooked rainbow trout was lower than 1 log cfu/g. Smoking reduced the *Enterobacteriaceae* count throughout the storage duration [20].

5. CONCLUSION

In conclusion, smoking fish can be used to prevent spoilage and fish damage. Smoking is a preservation method that uses smoke and heat materials. There are two methods of smoking, namely hot smoking and cold smoking. There are two types of smoke that can be used in fumigation, namely smoke and liquid. Hot smoking method uses a temperature of 30-90^{o}C, while cold smoking uses a temperature of 30-40^{o}C. The chemical composition contained in smoked fish is water content, protein, ash content, crude fiber, amino acids, biogenic amines, minerals and phenols. While the microbiological content of smoked fish with hot and cold smoking methods has a TPC value according to smoked fish standards and is free from pathogenic microbes, fungi, yeast and molds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adeyemi OT, Osilesi OO, Onajobi F, Adebawo O, Afolayan AJ. Stability study of smoked fish, horse mackerel (*Tachurus tachurus*) by different methods and storage at room temperature. Advanced Research Journal of Biochemistry Sciences. 2013;1(2):37-45.
2. Hush HH, Reilly A, Ben Embareck PK. Prevention and control of hazards in seafood. Food Control. 2000;11:149-156.
3. Berhimpon S, Montalalu RI, Dien HA, Mentang F, Meko AUI. Concentration and application methods of liquid smoke for exotic smoked Skipjack (*Katsuwonus pelamis L*.). International Food Research Journal. 2018;25(2):1864-1869.
4. Magawata I, Musa T. Quality characteristics of three hot smoked fish species using locally fabricated smoking kiln. International Journal of Fisheries and Aquatic Studies. 2015;2(5):88-92.
5. Ghazali RR, Swastawati F, Romadhon. Analysis the safety level of giant catfish (*Arius thalassinus*) treated with different smoking methods. Jurnal Pengolahan dan Bioteknologi Hasil Perikanan. 2014;3(4): 31-38.
6. Suroso E, Utomo TP, Hidayati S, Nuraini A. Fumigation of mackerel using liquid smoke from redestillated rubber wood. JPHPI. 2018;21(1):42-53.
7. Mareta DT, Awami SN. Pengawetan ikan bawal dengan pengasapan dan pemanggangan. Mediagro: Jurnal Ilmu Pertanian. 2011;7(2):33-47. ID
8. Nowsad AKMA. A new approach applied in the fish processing. Bangladesh Fisheries Research Forum; 2007.
9. Idah PA, Nwankwo I. Effect od smoke-drying temperatures and time on physical and nutritional quality parameters of Tilapia (*Oreochromis niloyicus*). International Journal of Fisheries and Aquaculture. 2013;5(3):29-34.
10. Lombok JZ, Setiaji B, Trisunaryani W, Wijaya K. Effect of pyrolisis temperature and destillation on character of coconut shell liquid smoke. Proceeding of International Conference on Research; 2014.
    ISBN.978-979-99314-8-1
11. Lingbeck JM, Cordero P, Bryan P, Johnson MG. Fuctionality of liquid smoke as an all-natural antimicrobial in food preservation. Meat Science. 2014;97(2): 197-206.
12. Adawyah. “Pengolahan Dan Pengawetan Ikan”. 2007. Jakarta: Bumi Aksara. ID Swastawati F. “Pengasapan menggunakan liquid smoke. Universitas Diponegoro, Semarang; 2008.
    ISBN: 979-704-473-3. ID
13. Erkan N, Uretener G, Alpas H, Selcuk A, Ozden O, Buzrul S. The effect of different high pressure condition on the quality and shelflife of cold smoked fish. Innovation Food Science and Emerging Technologies. 2011;12(2):104-110.
14. Iwegbue CMA, Tesi GO, Overah LC, Bassey FI, Nwadukwe FO, and Martincigh BC. Concentration and profiles of PAH in some popular fish species in Nigeria. Journal of Food Protection. 2015;75(9): 1619-1626.

15. Oyeleye OJ. Proximate compotition of some common hot smoked freshwater fish species using different packaging materials. International Journal of Fisheries and Aquaculture Research. 2020;6(2):29-39.
16. Simon R, Dela Calle B, Meier D, Anklam E. Composition and analysis of liquid smoke flavouring primary products. Journal of Seperation Science. 2005;28:871-882.
17. Martinez CC, Machado TJ. Consumer evaluation of cold smoked fat in beef sausages. International Food Research Journal. 2016;23(4):1782-1786.
18. Coban OE, Patir B. Antimicrobial and antioxidant effect of clove oil on sliced smoke Oncorhynchus mykiss. J. Verbr. Lebensm. 2013;8:195-199.
19. Ficicilar BB, Genccelep HA characterization study of hot smoked Rainbow Trout for Each Production Stages. International Journal of Agriculture Innovations and Research. 2017;6(2): 2319-1473.
20. Adeyeye SAO, Fayemi OE, Oyetoro AOA. Amino acid, vitain and mineral profiles of smoked fish as affected by smoking methods and fish types. Journal of Cullinary Science and Technology. 2018; 1-14.
21. Syam H, Patang. Analysis of the use of various types of fuel and smoking room temperature value of nutrition and organoleptic smoke Carp (*Cyprinuscarpio sp*.). 2018;11(5):414-420.
22. Jorgensen LV, Huss HH, Dalgaard P. The effect of biogenic amine production by single bacterial cultures and matabiosis on cold-smoked salmon. Journal of Applied Microbiology. 2000;0;89:920-934.
23. Usydus A, Szlinder-Richert J, Adamczyk M. Protein quality and amino acid profiles of fish product in Poland. Food Chemistry. 2009;112:139-145.
24. Polak-Juszczak L. Effect of processing methods on the content of mineras in fish product. Journal of Elementology. 2016; 21(2):461-470.
25. Mailoa MN, Sabahannur St, Halid I. Analysis total microbial and detection of salmonella on smoked fish. International Journal of Scientific and Technology Research. 2013;2(6):29-31.
26. Rukmayeni DA, Yniarti T, Sukarno. Application of liquid smoke from coconut shell in Tandipang (*Dussumeria acutta*) smoked fish to extend shelf life. JIPK; 2013;12(2):315-323.
27. Felix OA, Kehinde TA. Microbiological analysis of three of smoked fish obtained from the Ondo State, Nigeria. Food and Public Health. 2015;5:122-126
28. Emborg J, Dalgaard P. Formation of histamine and biogenic amines in cold-smoked tuna: an investigation of psychrotolerant bacteria from samples implicated in cases of histamine fish poisoning. Journal of Food Protection. 2006;69(4) 897-906
29. Dutta M, Mujumdar PR, Islam MR, Saha D. Bacterial and fungal population assesment in smoked fish during storage period. Journal of Food: Microbiology, Safety and Hygiene. 2018;3(1):127.
30. Joffraud JJ, Cardinal M, Cornet J, Chasles JS, Leon S, Gigout F, Leroi F. Effect of bacterial interactions on the spoilage of cold-smoked salmon. International Journal of Food Microbiology. 2006;112(1):51-61
31. Sahubawa L, Ustadi. Teknologi Pengawetan dan Pengolahan Hasil Perikanan". Yogyakarta: Gadjah Mada University Press; 2018.ID

Peer-review history:
The peer review history for this paper can be accessed here:
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