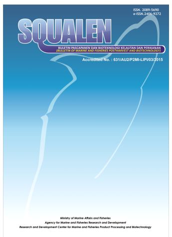

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Physicochemical and Microbiological Evaluation on Frozen Tuna Loin Handling in Ambon, Indonesia

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Abstract

Tuna fisheries plays an important role in economic and social development in Indonesia. Ambon is one of important tuna landing places in Indonesia. Tuna fishing in Ambon is mostly conducted by small scale fishers using small boats (1.5 GT) and traditional pole and line. The caught tuna is loined on board and collected at landing post or mini-plant before being sent to Fish Processing Unit (FPU) in Ambon, Indonesia. The study was aimed to evaluate the handling of tuna loin at small scale fishermen which was used as raw material for frozen tuna industry. Two type of tuna loin, namely skin-on and skinless tuna loin were obtained from landing post in Latuhalat and Tial districts in Ambon island which have stored in ice overnight. Tuna loins were sent to be frozen to FPU at Ambon city. Observations were performed on the physical, chemical properties, as well as sensory parameter of tuna loin at each processing steps, starting from (1) landing and handling at the collecting level, (2) after skinning and trimming before CO treatment, (3) after treating with CO and incubation in chilling room and (4) frozen tuna loin products. The result showed that the existing tuna handling during processing and freezing decreased the caused quality of the frozen tuna. Frozen skinless loins had better quality than frozen skin-on tuna loins. The quality of tuna loin decreased rapidly during incubation process after CO treatment showing by the decrease of sensory values, increased of TVB as well as the increased of bacterial content. However, the frozen tuna loin products still comply with the requirements for frozen tuna based on Indonesian National Standard 01.2346-2006.

Keywords: Frozen tuna loin, skin-on, skinless, Ambon Indonesia

1. Introduction

Indonesia is the largest tuna producer in the world, with production reaching 16 percent of total world production (Handoko, 2019). One of the largest tuna producers area in Indonesia is Ambon. It was reported that in March 2019, Ambon exported almost 10 tons of fresh tuna for sashimi to Japan (Anon., 2019). Tuna catch in Ambon is mostly conducted by small scale fishermen using pole and line fishing gear. The tuna catch was usually one day fishing using a small boat with a length of 7-8 meters and a width of 1-1.5 m with the fishing capacity ranges from 1.5 to 2 Gross Ton. Caught tuna was then immediately killed by hitting on the head and cut into 4 loins, and stored with crushed ice in styrofoam boxes. The quality of tuna loin can be maintained by lowering the internal temperature which was faster than the whole tuna.

Mostly, raw material of frozen tuna processed by FPU (Fish Processing Units) in Ambon city is obtained from tuna loin collector in the form of loin rather than whole fish. Tuna loin is easily contaminated by spoilage bacteria, so that the rate of decomposition will be faster than whole form tuna, especially if the cold chain system is not conducted properly (Ilyas, 1986). One factor that plays an important role in maintaining the quality of tuna was the handling at the initial level, starting from tuna caught, killed, bleed and chilled at 4.4 °C (Blanc, Desurman & Beverly, 2005). The problem was the size of tuna fishing boat in Ambon, which was small and not equipped with roof and insulated fish hold. As a result, the handling of tuna may not conducted properly and the cooling process performed was not able to decrease the internal temperature of the tuna loin rapidly. For tuna sashimi, the tuna required to have temperature of 4.4 ^{o}C as stated by SNI 01-4103.3-2006 (BSN, 2006).

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Tuna caught by fisherman was landed at landing post or mini-plant known as a household scale tuna loin processing unit. The skin-on tuna loin obtained from the fishermen was processed into a skinless loin by removing the skin, bones and red flesh and then put into the plastic and stored in ice overnight. Some other landing posts or mini-plants processed the tuna loin only by replacing the plastic and remove the dirty material then stored in ice overnight and sent to the fish processing unit in Ambon in the next day. Study on the handling and processing of fresh tuna loin on the small boat at collector level in the village of Asilulu Ambon was conducted by Siregar, Siregar, and Zahro (2014). This study found that the trimming process at collector level was carried out in unsanitary way e.g. washing the equipment using unclean sea water. This condition does not meet the requirement standar of supply chain of tuna loin in Ambon (Jati, Nuraini & Iskandar, 2014). However study on the physicochemical and microbial evaluation have not been done. The objective of this study was to evaluate the handling of tuna loin (skin-on and skinless) as raw materials at the collectors level and its effect to the physicochemical and microbiological properties of the frozen tuna loin.

2. Materials and Method

2.1. Materials

Material used in this research was yellow fin tuna (*Thunnus albacares*) in the form of skin-on and skinless loin. Skin-on tuna loin was obtained from collectors in Latuhalat Village, Ambon City (Figure 1) while skinless tuna loin was obtained from collectors in Tial Village, Ambon City. Other materials used for analysis were Sansui KIT media for Total Viable Count analysis and Sanita Kun kit for *Escherichia coli* and *Salmonella*. Chemicals used for TVB, protein and fat analysis were in p.a. grade.

2.2. Method

Data collection was performed at each stage of frozen tuna processing, starting from (A) landing and handling at the collecting level (B) after skinning and trimming before CO treatment (C) treating with CO and incubating in chilling room for 2 days before freezing (D) frozen tuna loin products. The frozen tuna processing was conducted in PT. Harta Samudra which located in Ambon, Indonesia which has HACCP certificate (grade A) for Fish Processing Unit.

2.2.1. Procedures for frozen tuna processing

Skin-on and skinless tuna from collectors which have been stored in ice overnight were transported to PT. Harta Samudra FPU. Before transferred into the processing room, tuna loin (still wrapped in plastic) was dipped into 200 ppm of chlorine solution then frozen. The skin-on tuna loin was then skinned and trimmed to remove the skin, bone, red meat, belly and brown meat. Meanwhile, the skinless loin was trimmed only to remove the brown meat. Tuna loin was then weighed, treated with CO, wrapped with paper and put into special plastic packaging for tuna. Tuna loin was then stored in chilling room (temperature of 1.12 °C) for 2 days, so the color of tuna flesh turned into bright red. After that, tuna loin was trimmed again,

Figure 1. Sampling Location.

packed in the plastic bag and frozen. Freezing of tuna loin was conducted by Air Blast Freezer (temperature -35 °C) for 8 hours. Frozen tuna loin was then stored in a cold storage (temperature -25 °C), then packed in styrofoam box and wrapped with plastic sheets before sent to Jakarta, Indoensia by plane.

2.2.2. Parameters of analysis

Observation on the quality of the raw material tuna loin was conducted on proximate analysis consisting of moisture content (SNI 01-2354.2-2006), ash content (SNI 01-2354.1-2006), protein content (SNI 01-2354.4-2006) and fat content (SNI 01-2354.3-2006) (BSN, 2006). Observation at each stage of the process was carried out on the temperature of the center of tuna loin using infrared thermometer, moisture content using moisture infrared sensor, pH using pH meter, TVB using conway method (Yunizal et al., 1998) and sensory test of fresh or cooked tuna by scoring test (SNI 01.2693.1-2006) (BSN, 2006). Total viable count parameter was observed using *Sansui* Kit media. After inoculated the media was incubated at 35 °C for 48 hours (Anon., 2010). *E. coli* and *Salmonella* test using Sanita Kun Kit media. After inoculation the media sheet was incubated at 35 °C for 24 hours (Ushiyama & Iwaki, 2010*;* Anon*.,* 2010*).* Positive colonies were then reverified. For *E. coli,* it was grown in eosin methylene blue agar (EMB) medium, while for *Salmonella sp.,* it was grown in lysine iron agar medium (LIA) and triple sugar iron agar (TSIA).

3. Results and Discussion

3.1. Proximate Analysis of Tuna Loin as Raw Material

The proximate values of fresh tuna, i.e moisture, ash, protein and fat content are presented in Table 1. The moisture content of skin-on tuna loin was 73.14 ± 0.22%, while for skinless tuna loin was 75.05 ± 1.34%. The results were similar to moisture content of yellow tuna observed by Karunarathna and Attygalle (2010) which was 74.44 ± 1.44 %. The average moisture content of skinless tuna loin was higher than the skin-on tuna loin. This phenomenon happend caused by the decrease of protein ability to bind water due to protein denaturation in skinless tuna loin which occurred at low temperatures (Watson, Bourke, and Brill, 1988). The fat content of the skin-on tuna loin was 0.95 ± 0.09 % and the skinless tuna loin was 0.54 ± 0.4%. The fat content in both forms was considerably low less than 1%. Therefore, in trading, yellow fin tuna was categorized in grade 3 which is relatively cheaper compared to blue-fin tuna and big eyes tuna. The protein content of yellow fin tuna captured in Ambon was relatively high. The skin-on tuna loin was 26.19 ± 0.14 % and skinless tuna loin was 24.34 ± 077 %. This level was not much different from the protein level of yellow fin tuna ranging between 24-25% (Karunarathna & Attygalle, 2010).

3.2. Temperature of Tuna Loin at Each Processing Stage

Temperature is the main factor influencing the quality and spoilage of tuna loin. The observation on the center of tuna loin temperature showed that landed tuna loin had temperature between 15.1 and 14.6 °C (Figure 1). The temperature was above the fresh tuna temperature for sashimi 4.4 °C (SNI 01.2693.2006). High temperature of tuna loin might be caused by the process of handling on board, especially when fish were caught, killed and bleed. According to the fisherman, the fish was killed and allowed to struggle for 15 minutes until the fish was death. This killing method will cause stressed and glycogen metabolism occurs and temperature of the fish body rise in a short time to 35-40 °C (Wibowo et al., 2007).

According to Irianto (2008) ideally after being caught, fish should be lifted into the deck of the boat then lay on soft foam before killed using a spike by piercing the brain to damage the nerve. Bleeding was done by cutting blood vessels on both sides of the body behind the pectoral fin, so the blood came out perfectly and can reduce the temperature of tuna due to the glycogen metabolism. However, due to small size of boat, this procedure cannot be conducted. The

Table 1. Proximate values of the skin-on and skinless fresh tuna loin

Parameters	Skin-on tuna loin	Skinless tuna loin
Moisture content (%)	73.14 ± 0.22	75.05 ± 1.34
Ash content (%)	1.33 ± 0.07	1.34 ± 0.08
Protein content (%)	26.19 ± 0.14	24.34 ± 0.77
Fat content (%)	0.95 ± 0.09	0.54 ± 0.24

Note: The measurement conducted in 3 replications

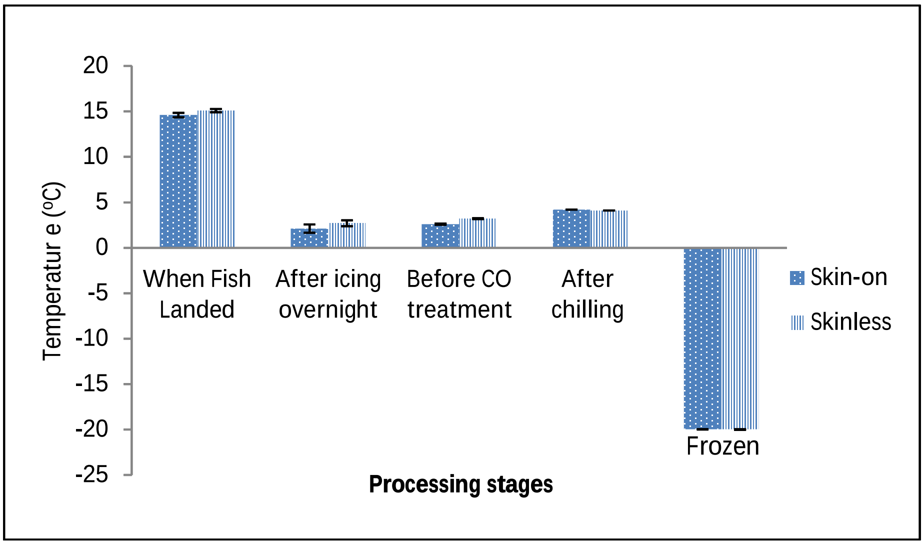

Figure 2. Changes of the internal temperature of the loin during the process stages

high temperature of tuna loin indicating that the ice used was not able to lower the internal temperature of the tuna loin into 4.4 °C as recommended by SNI 01.2693.2006. According to the fisherman, the trip duration from fishing ground to the fish post landing is about 4 hours. Commonly, fishermen crushed ice to chill the tuna loin which has low cooling rate. The best ice used to chill tuna loin is slurry ice, which has lower temperature, faster cooling capacity, higher heat transfer rates, as well as completely covers the fish surface (Medina, Gallardo, & Aubourg, 2009). Davies (2005) studied the cooling of 30 kg cod fish using the slurry ice with 3 % salt solution and 35 % ice grain, the temperature of slurry ice was -2.6 °C, and the temperature center of fish reached 0 °C for less than 2 hours. Slurry ice has a cooling rate 3 times faster than ice flake (Margeirsson & Matis 2008). Slurry ice is best to use at the beginning of storing to cool down fish temperature, as it is reduce the temperature faster than ice flake (Margeirsson & Matis 2017). The fish container used by Ambones fisherman is styrofoam which the more its used, the less its isulated the older. The result also showed that the styrofoam used for fish storage had been used for long time and has decreased the insulated ability. This was exacerbate by the hot weather during tuna catching, whereas the fishing vessels were not equipped with sun roof. This caused the cooling system on the boat not working properly.

After the tuna loin was stored in ice overnight, the center of the skin-on tuna loin temperature was dropped to 2.1 °C, while the skinless tuna loin was slightly higher (2.7 °C). After the cleaning process, the center of tuna loin temperature rose 0.5 °C to 2.6 °C (skin-on) and 3.2 °C (skinless)due to high temperature in the processing room which was 24 °C. The processing room temperature should not be higher than 16 °C, and should not be lower than 10 °C (Valtysdottir et al., 2010). The temperature of tuna loin might increase to 6-7 °C /h if the temperature of processing room higher than 20 °C (Gang, 2013). In this study although the temperature of the tuna loin was increased, however it was still below 4.4 °C, so it still safe from the histamine-formation risk during processing. The internal temperature of fish is a critical point and a key factor to maintain the quality of tuna loin and to prevent bacterial growth as well as histamine formation (Mc Lauchin et al., 2005). Histamine will not be formed if fish are kept at temperatures below 5 °C (Huss, 1998).

The temperature of tuna loin was slightly rose to 4.1 - 4.2 °C after treated with CO and incubated in chilling room for 2 days (the temperature of chilling room ranges from 1 to 1.2 °C). The increased temperature of tuna loin during incubation, has caused psychrophylic bacteria to grow the faster. Observation to the internal temperature of frozen tuna loin showed that both skin-on and skinless tuna loin have the same temperature that was -20 °C. This temperature is in accordance with the SNI standard requitment of the internal temperature of frozen tuna loin i.e -18 °C (SNI 01-4104.3-2006; BSN, 2006).

3.3. TVB Content

The analysis result of TVB content on tuna loin was shown in Figure 3. When tuna loin was landed in landing post, the TVB content was less than 10 mgN%, indicating that the fish was still in prime quality (Dalgaard, 2000). The TVB content on skin-on tuna loin was higher (9.62 mgN%) than on skinless tuna

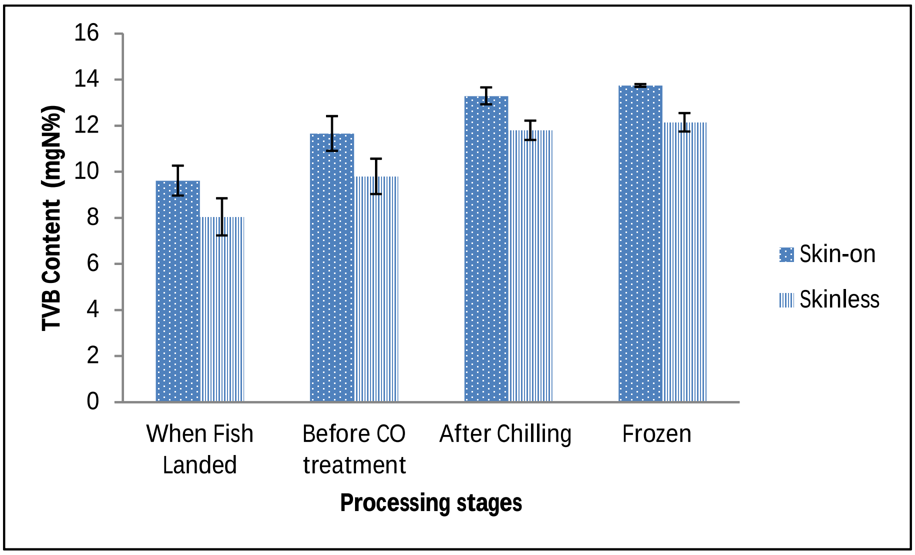

Figure 3. TVB content of tuna loin during freezing process.

loin (8,04 mgN%). The TVB content increased at each stage of the processing, both for the skin-on and skinless tuna loin. After tuna loin was stored in ice overnight, before treated with CO, the TVB value of the skinless tuna loin slightly increased from 8.04 to 9.8 mgN%, showed that the fish was still in prime quality. However, when tuna loin was incubated in chilling room after treated with CO the TVB value was then increased rapidly from 9.68 to 11.66 mgN% on skin-on tuna loin indicating that the fish was no longer in prime quality. After incubation at chilling room, the TVB content of skin-on tuna loin was recorded 13.29 mgN% and skinless tuna loin was 11.8 mgN%. Based on the value of TVB, the freshness of the fish dropped from prime quality (very fresh) with TVB content of 10 mgN%, to fresh fish with TVB content of 10-20 mgN% (Dalgaard, 2000). Increasing TVB content can be associated with increasing bacterial content that occurs rapidly during incubation at chilling room for 2 days (Table 2). The increase of TVB has caused the degradation of trimethyl amine oxide (TMAO) to DMA compound produced by autolytic enzyme and TMA produced by spoilage bacteria. Amonia was produced by the deamination of free amino acids and nucleotide catabolites and peptides by partial proteolysis during icing overnight (Etienne, Ifremer, & Nantes, 2005). TMAO is non-protein nitrogen compound contained in fish and other marine fishery products. Fish use TMAO as an osmo-regulator to prevent dehydration in the seawater environment (Huss, 1998).

In fish spoilage process, microorganisms utilize the oxygen atoms donated by TMAO under anaerobe conditions and result in the formation of TMA resulting *in* the increase of TVB content (Adams & Moss, 2008 in Murtini et al., 2014). During the freezing process, the TVB content of frozen tuna loin slightly increased because the degradation of TMAO into DMA and TMA can still occur at -20 °C (Ghaly, 2010). The TVB content of skin-on frozen tuna loin was 13.74. mgN% while skinless frozen tuna loin was 12.15 mgN%. The TVB content is still below 20 mgN% indicating that the quality deterioration of tuna is still at an early stage and can be categorized as fresh tuna loin (Dalgaard, 2000). Meanwhile, according to East African Standard TVB content for frozen tuna loin is still acceptable at 35 mgN% (Anon., 2010).

3.4. pH of Tuna Loin

The results of pH measurement during processing are presented in Figure 4. When tuna was landed in landing post, pH of skin-on tuna loin was lower (5.98) than skinless tuna loin (6.2). The pH value can be attributed to the tuna catching and killing process. Fish that suffer from prolonged stress before death resulting in the process of glycolysis and produce lactic acid that accumulates in the blood, causing fast decrease of pH value of fresh tuna (Wibowo et al., 2007; Maeda et al., 2014). Tuna loin pH after post mortem can reach below 6 (Menzano et al., 2000). According to Watson et al. (1988) tuna is classified as good quality if the pH value is more than 5.7. In this study pH value of skin-on tuna loin is 5.98; lower than skinless tuna loin with 6.2. The pH of tuna loin is still above 5.7 means that the tuna loin was still considered to have a good quality.

During freezing process the pH was fluctually decreased. During ice storage, the pH of skin-on tuna loin slightly decrease from 5.98 to 5.95; while skinless tuna loin decrease from 6.2 to 5.96. After tuna loin was treated with CO and incubated in chilling room for 2 days the pH slightly increased, skin-on tuna loin

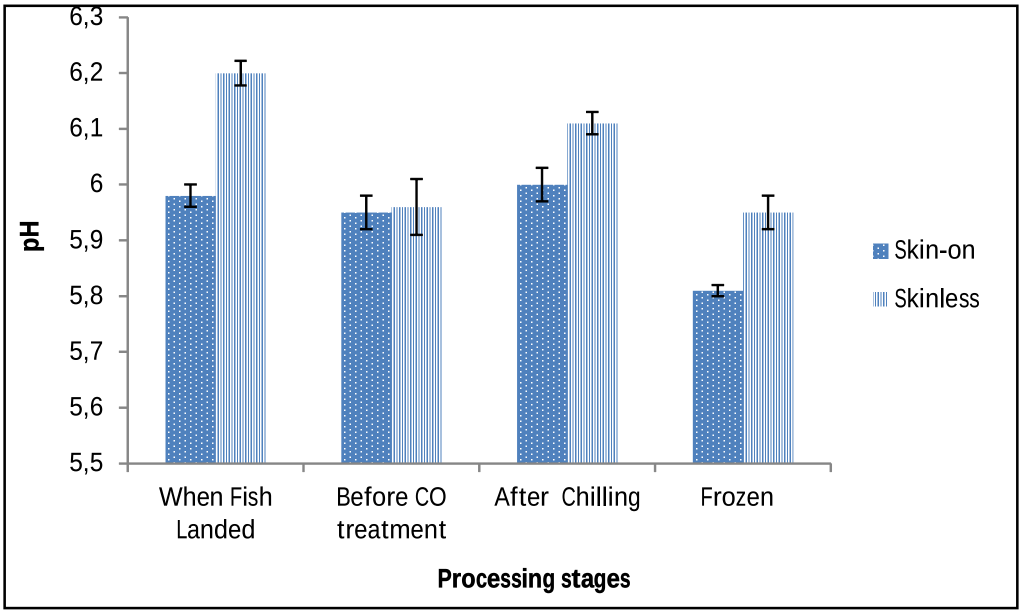

Figure 4. pH of tuna loin during freezing process.

became 6.0 and skinless tuna loin became 6.11. The frozen tuna loin pH produced from skinless tuna had pH of 5.95 while frozen tuna loin produced from tuna skin-on had pH 5.81. The decrease in pH during processing is due to the biochemical process that still occurs during processing, producing lactic acid which may have an effect on the decrease of pH. (Watson et al., 1988). Decrease of the pH value will affect to the organoleptic value, especially on taste, color and appearance of the product. If the pH of tuna loin was low, it will stimulate proteolysis Catepsin enzyme to break down actin and myosin which causes protein denaturation and the color of meat became yake (brown meat) thus affected the appearance of the meat.

3.5. Total Bacteria of Tuna Loin During Frozen Processing

The observation on the total bacteria of tuna loin during freezing process is shown in Table 2. The total bacteria of skin-on tuna loin and skinless tuna loin when landed at landing post were 3.4 x 10^4 CFU/g and 1.15 x 10^4 CFU/g respectively. When the fish is still alive, the bacteria are found on the gill, skin and in the intestine and they cannot attack the fish muscle (Quang, 2005), but soon after death, million of bacteria from that area invade the fish tissue causing spoilage (Dhanya & Mathew, 2017). The high number of bacteria on skin-on tuna loin was probably due to contamination from the gastrointestinal contents as well as from the skin. According to Austin (2002) the amount of bacteria in the gastrointestinal tract can reach 10^8 CFU/g for heterotrophic bacteria and 10^5colony/g for anaerobe bacteria. The number of bacteria on the skin is close to the number of bacteria in the water where the fish live, ranging from 10^2 to10^4 colonies/g which can contaminate tuna loin meat.

After stored in ice overnight or before CO injection, the number of bacteria in skin-on and skinless tuna loin was increased which was 7.2 x 10^4 CFU/g and 9.2 x 10^4 colony/g, respectively. The number of bacteria has increased rapidly after tuna loin was injected with CO and stored in chilling room for 2 days to get the red color of the tuna meat. The bacteria number of tuna loin skin-on was 8.2 x 10^6 CFU/g and skinless tuna loin was 1.48 x 10 ^{6} CFU/g. The increase of the bacteria number was probably due to the chilling temperature which was ranging from 1 to 1.2 ^{o}C. This temperature is relatively high for incubation, the chilling temperature used for incubation should be ranges between -0.5 and 0 ^{o}C (Huss, 1998). During incubation process, the temperature of tuna loin center rose to 4.1-4.2 ^{o}C, thus the psycrophilic bacteria could multiply at that temperature. According to Gram and Huss (1996) not all the bacteria are involved in the spoiled process, after overnight ice storage in aerobic condition the *Pseudomonas* sp. and *Shewanella putrifaciens* bacteria will become the predominant bacteria. However, the number of bacteria decreased after freezing process. This is because freezing process can reduce the fish center temperature to -20 ^{o}C. Freezing have a lethal or inhibitory effect on microbiological systems. Some cells may express no detrimental effects, some are killed, and some may undergo sub lethal or metabolic injury. Not all bacteria

Table 2. Microbiological content of tuna loin during process

	Total Viable Count (colony/g)	*Salmonella* (colony/g)	*E coli* (colony/g)	Coliform (Most probable number/100 ml)
Skin-on Tuna Loin				
When Fish Landed	3.40 x10^4	Negative	Negative	15
Before CO treatment	7.20 x 10^4	Negative	Negative	0
After incubation	8.20 x 10^6	Negative	Negative	23
Frozen tuna loin	7.50 x 10^3	Negative	Negative	1
Skinless Tuna Loin				
When Fish Landed	1.14 x 10^4	Negative	Negative	18
Before CO treatment	9.20 x 10^4	Negative	Negative	14
After incubation	1.48 x 10^{6}	Negative	Negative	12
Frozen tuna loin	3.20 x 10^3	Negative	Negative	0

Tabel 3. Swab analysis on the facilities used for processing in Fish Processing Unit of PT Harta Samudra

Note	Total Viable Count (cfu/g)	Salmonella (colony/g)	E.coli(colony /g)	Coliform (Most probable number /100 ml)
Table swab	8.6 x 10^2	Negative	Negative	0
Knife swab	5.2 x 10^2	Negative	Negative	1
Balance swab	6.6 x 10^2	Negative	Negative	19
Labor swab	< 10^1	Negative	Negative	0
Ice swab	2.0 x 10^2	Negative	Negative	2

killed by freezing, the remaining bacteria the will quickly grow during thawing (Goli & Nguyen, 2004). According to Mas'ud (2010) the freezing process caused sub lethal damage on some cells. The most lethal freezing temperature, where the highest number of cells is dead, is between -2 to -20°C. The number of bacteria in skin-on tuna loin was 7.5 x 10^3 CFU/g; slightly higher than skinless tuna loin with 3.2 x 10^3 CFU/g. In this research, the freezing process was done using Air Blast Freezer (ABF) where the freezing temperature can reach -40°C. Meanwhile, the temperature of the frozen storage is -25°C, so that the number of bacteria in the frozen tuna loin undergoes sub lethal or death.

According to Bao, Arason, and Lorarinsdottir (2007) the resistance of microorganism cells to freezing process was influenced by the ability of these microorganisms to survive during dehydration at the time of frozen stage. The bacteria contained in the frozen tuna loin are psychrophilic bacteria which can grow at low temperatures around -5 to -20°C. Common bacterial species grown in fish stored at cold and decaying temperatures are *Pseudomonas putrefaciens, Pseudomonas flourecens, Moraxella sp, Acinobacter sp, Alcaligenes sp* (Ghaly et al., 2010), whereas according to Huss (1998) the most common form of psychrophilic bacteria causing fish spoilage is Gram-negative organisms, primarily *Pseudomonas spp, Shewanella putrefaciens* and *Photobacterium phosphoreum.*

Observation of pathogens bacteria *E. coli* and *Salmonella* sp indicated negative results, while the number of Coliform bacteria ranged from 0-23 MPN/ g. According East African Standard Frozen Tuna Specification (Anon, 2010) this amount is still within the standard limit for frozen tuna loin for coliform which are 100 MPN/g. This coliform bacteria probably comes from the digestive tract or cross contamination with the facilities and infrastructure that were used. The number of bacteria obtained from facilities and infrastructure used in PT Harta Samudra were 52-86 x 10^2 CFU/g, which shows that sanitation is well maintained. The bacteria number of ice used for fish preservation is detected 2 x 10^2 CFU/g which is still within the SNI 01 4872.1 2006 (BSN) requirements. The result of swab analysis of facilities used for processing of frozen tuna are presented in Table 3.

PT. Harta Samudra is a fish Processing unit who have implemented the HCCP system and classified as Grade A. Grade A is the highest level of certificate of HCCP that the resulted from the assessment of physical, SSOP, GMP, HACCP. The grade explains that there is no criteria categorized as serious and critical, with maximum minor deviations of 6 and maximum major deviations 5. Fish Processing Unit which is classified as grade A allowed to export to other countries with certain requirements including the European Union (Laismina, 2014).

3.6. Sensory Test for Tuna Loin During Freezing Process

The results on the sensory observation on appearance, texture, odor and taste (1-9 scale scoring test) are presented in Figure 5.

3.6.1. Appearance

The quality of tuna loin can be determined by its color which can also be seen from the presence of rainbow layer as well as the muscle tissue of tuna loin. The high value of fresh tuna (grade A) is attributed to the red color which is primarily due to the presence of relatively large amounts of myoglobin. In this grade, the appearance of tuna loin should have a moist, shiny, and translucent meat looks. All those criteria should be met when tuna loin was landed. In this study, panelists gave the value of appearance on skinless tuna loin of 8.3 or less than 9 due to the presence of thin layer of rainbow on fish surface so the red color is less brilliant and shiny. While panelist gave score 8 for skin-on tuna loin due to the availability of clear rainbow layers on the surface and the red color of tuna was slightly dull and less shiny. The thin layer rainbow on the flesh was caused by on board handling, especially when fish were caught before killed. Struggling tuna while being caught caused the fish were stressed and under stressed conditions the fish will release *catechol amines compounds* that trigger the occurrence of troponin phosphorylation that looks like a thin layer of rainbow (Watson et al., 1988). When tuna loin was stored in ice overnight before treated with CO, the appearance of skin-on tuna decreased to 7.6 because the rainbow was thicker and covered the surface thus the red color was rather dull. This dull color is probably caused from the tuna skin when tuna loin was stored in ice overnight. After treated with CO and incubated at chilling temperature for 2 days the panelists gave the same score as landed stage. The color of tuna loin meat was turning into deep red, shiny and less translucent compared to the color before incubation. After the tuna loin was frozen the panelists scored the appearance attribute 8 for tuna loin skinless and 7.6 for tuna loin skin-on. The meat of muscle tissue of skin-on tuna loin was separate into flakes.

3.6.2. Texture

The observation of the texture indicates that during processing of frozen tuna loin, panelist gave a decrease value of texture. Skin-on tuna loin decreased faster than skinless tuna loin. When tuna loin was landed in mini-plant, panelists scored texture attribute for both skin-on and skinless tuna loin about 8.6. However, after the fish was iced over night and injected with CO, the texture of skin-on tuna loin decreased from 8.6 to 8.3, but for the skinless tuna loin, the panelist still gave 8,6. After tuna loin was injected with CO and incubated for 2 days in chilling room, the panelists gave texture value for skin-on tuna loin 7.6 and skin les 8. The decrease of texture value was because the texture of tuna loin was less compact. This can becaused lower pH of tuna that can stimulate proteolytic cathepsin enzymes and damage the muscle tissue structure of fish meat (Huss, 1988). The decrease in meat texture of tuna was associated with loss of Z bands in muscle cells after rigor mortis due to the release of actinin which separates the actin-myosin complex which causes the texture to be less elastic (Tanako & Osako, 2008). Panelists gave the value of frozen tuna texture with skin-on was 7.3 and skinless tuna was 8, still including for fresh tuna category according on SNI 01.2346-2006 (BSN, 2006). The decrease in texture value in frozen tuna loin caused by freezing can cause ice crystals, which can damage the fish cell wall. When tuna loin was thawed, muscle tissue is less compact and affects the texture of fish.

3.6.3. Odor

The observation on tuna loin odor indicated that the panelists gave higher odor values on skinless tuna loin products compared to skin-on tuna loin. When tuna loin was landed the odor of tuna loin had a typical very specific fresh smell. Panelists gave the odor value of the skin-on tuna loin i.e 8.3 and skinless tuna loin 8.6, meaning that the odor of tuna loin meat was very fresh. The odor of tuna loin decreased when the tuna was kept in ice overnight before treated with CO. The panelist gave lower the odor value of skin-on from 8 to 7,6, whereas skinless tuna loin from 8.3 to 8.

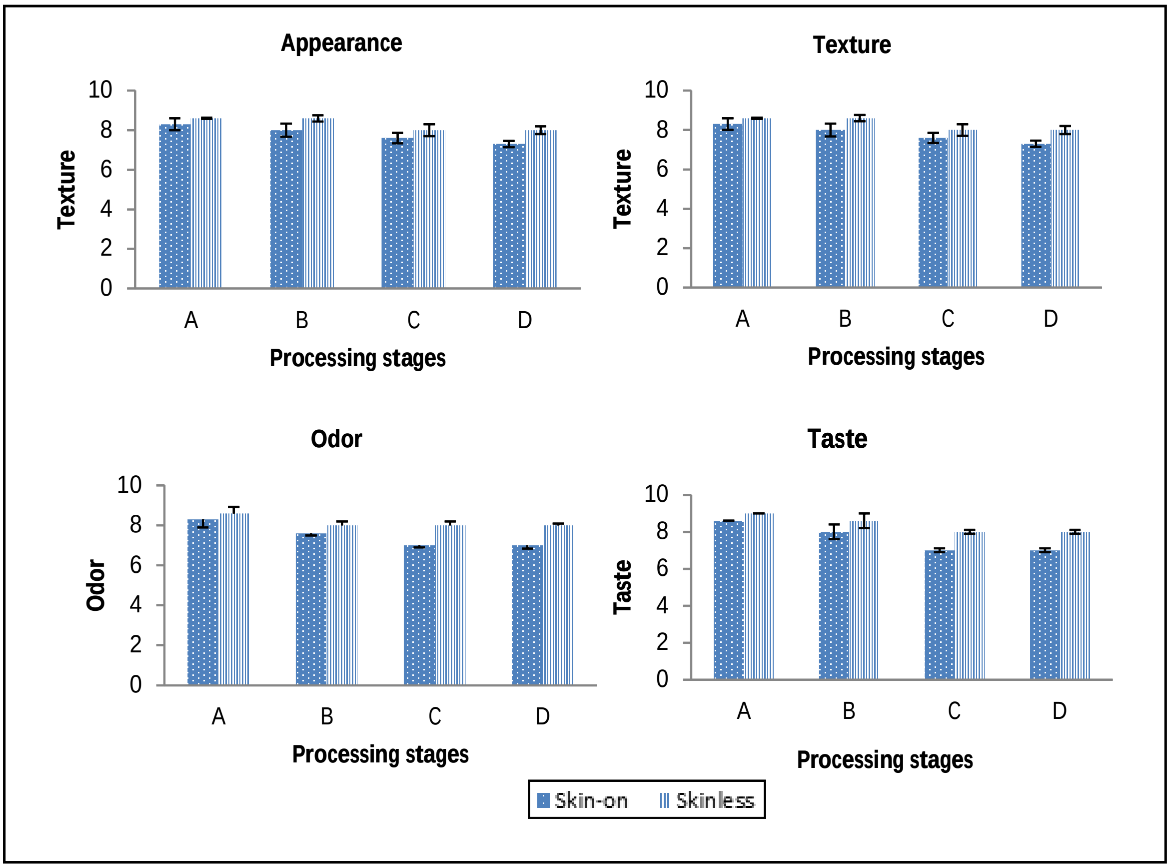

Figure 5. Sensory value of tuna loin during freezing process.

During incubation and freezing process the odor value of skin tuna loin decreased to 7, meaning that the odor of fish was fresh and had a typical specific odor. For skinless tuna loin frozen product, panelist still gave value of 8, indicating that some panelist determined the smell of tuna loin was very fresh. The value is still categorized as fresh for frozen tuna loin according to SNI 01.2346-2006. The low odor value of skin-on tuna loin frozen product was caused by a little fishy odor of this fish. This is because of the action of spoiled bacteria that break down the compound of trimethylamine oxide, an odorless compound, into trimethylamine compound which has fishy smell (Jinadasa, 2014). It is supported by the number of bacteria and TVB content which was higher in skin-on tuna loin than skinless tuna loin.

3.6.4.Taste

When the tuna loin landed panelists gave value of 8.6 for skin-on tuna loin and 9 for skinless tuna loin, which showed that the panelists could taste the savory and sweet taste of the fresh tuna that was landed. During processing the value of tuna loin taste decreased, which is caused by the loss of sweet taste in the tuna loin. The rapid decrease of tuna loin taste values occurred when tuna loin was incubated in chilling room for 2 days. Panelists give a value of 7 for the skin-on tuna loin which means it had savory taste, no extra flavor but tuna loin loses its sweetness. For the skinless tuna loin, panelists give a value of 8 which means most of the panelists can still feel the sweet taste of fish meat. During the freezing process, no taste was changed. Panelist gave the same taste value of frozen tuna as that of tuna loin after 2 days incubation in chilling room. This decrease in taste was due to the oxidation process of unsaturated and non-enzymatic unsaturated fatty acids in fish muscles resulting in carbonyl, alcohol, and other variations that causes the changes in meat taste (Tanako and Osako, 2008).

4. Conclusion

The study found that different treatments (skin-on and skinless) did not effect the proximate, physical (temperature and pH) of final frozen tuna, however skin-on tuna treatment had higher TVB and Total Viable Content of the bacteria compared to skinless treatment frozen product. Using skinless tuna loin as raw material produced a better sensory and TVB content of frozen tuna loin. During processing the quality of frozen tuna loin product, decreased rapidly primary during the chlilling process CO treatment.

Ther for, incubation/ chilling process is critical point in the processing of frozen tuna loin However, all frozen tuna loin product resulted in the study were still meeting the requirements of SNI 01.2346-2006 for frozen tuna.

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