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Physical-Chemical Assessment Freshness of Skipjack Fish (*Katsuwonus pelamis*) Marketed in the Capture Area of South Sulawesi, Indonesia

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Abstract: ***The catches of skipjack fish are one of the highest catches of fish in the area of South Sulawesi including the West Coast fish landing areas in Makassar, Pare-Pare, and the East Coast in Sinjai, and Palopo. Fish landed by fishers are then marketed to traditional markets. The purpose of this study was to analyze the physical-chemical quality of skipjack fish landed in the area of South Sulawesi until it was marketed for eight hours. In this study, the physical-chemical analysis measured to determine fish quality was temperature, pH, organoleptic, peroxide number, and TVB. The overall results showed that there was a decrease in the quality of skipjack fish due to an increase in temperature of 3-4 ^{o}C, a decrease in pH reaching 5.0-5.7, an increase in the peroxide number of 25.3-27.3 mEq/g and an increase in TVB 9.3-12.0 mg/100, and a decrease organoleptic value 5.9-6.3 at the end of the sale. Even so, fresh skipjack is still categorized as suitable for consumption and sale. From this study, it is recommended to improve the handling process by using a proper container and adjusting the amount of ice to maintain the temperature during the sales process.***

Keywords: skipjack, freshness quality, physical and chemical assessment, landed fish area

1. Introduction

The Skipjack fish (Katsuwonus pelamis) is a high economic value fish and has complete nutritional content with abundant protein, low-fat content, most of its fatty acid composition is omega-3, and essential minerals for the body are Fe, Cu, and Zn [1]. This fish has an enormous contribution to the world's food needs in addition to its nutrition, also indicated by the third highest number of catches in the world in 2016 that is 2.83 million tons [2] and fourth rank with catches in 2016, 117.73 thousand tons in Indonesia [3].

Distribution of skipjack is mostly in the tropics and at moderate temperatures [4]. The second largest contributor to the catch of skipjack fish comes from Indonesia [2]). Skipjack fish are often caught in catchments in Indonesia, including in the catchment area of South Sulawesi. The division of catchment areas in South Sulawesi is divided into the west coast and the east coast. The west coast catchment area includes the city of Makassar and Pare-Pare, and the eastern namely region of Sinjai, and the City of Palopo.

Fresh skipjack obtained from catches in the catchment area in South Sulawesi and subsequently is marketed to traditional markets. Consumer needs for fresh fish and food security require market players to be able to maintain the freshness of the fish until it reaches consumers. Skipjack tuna is the same thing as other fresh fish which are easily damaged due to decay due to high water activity (aw), neutral pH, low connective tissue content, and the presence of autolytic enzymes [5].

Changes in the quality of fresh fish begin shortly after the fish is caught/harvested. The freshness of fish is a significant factor in seafood end products that are influenced by rigor mortise and post-death autolysis processes, which can accelerate the decline in fish quality [5] [6]. The rapid decline in the quality of fresh fish is also due to the handling and storage methods applied [7] [8]. Handling of fresh fish is generally done traditionally with the provision of ice stacks [9]. The advantage of using ice as a cooling principle is that besides being readily available and affordable, it is also reported to reduce the temperature [10], inhibiting the rate of enzyme activity [11], helping to control microorganisms and decay, and keeping fish meat characteristics unchanged [12]. However, giving ice has not been the best treatment for all fish, depending on the type and size of the fish, and the season.

Several assessments, namely physical-chemical assessment, largely determine the quality of fresh fish. Assessment of fish quality when handling is done by measuring physical-chemical indicators, including fish temperature, pH, peroxide value, organoleptic, and TVB. At present, there is limited information available regarding physical assessment for traditional handling of fresh fish in catchments in Indonesia. Thus, this study aims to evaluate the physical-chemical assessment of the quality of fresh skipjack marketed in the fishing area of South Sulawesi, Indonesia.

2. Materials and Methods

2.1 Fishing ground area

The caught skipjack fish originates from the South Sulawesi fishing area on the West Coast (WC) covering the area of Makassar and Pare-Pare City, East Coast (EC) covering Sinjai District, and Palopo City is presented (Figure 1). They are catching fresh skipjack on the West Coast using purse seine while on the East Coast using pole and line fishing gear.

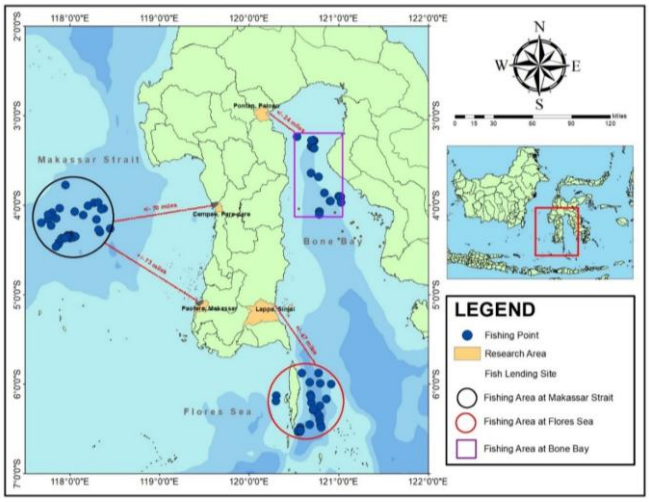

Figure 1: Location of the skipjack catchment area in the fishing area of South Sulawesi

2.2 Skipjack fish

Fresh caught skipjack fish are landed at fish landing sites in the South Sulawesi region, namely the landing sites of Makassar City, Pare-Pare City, Sinjai District, and Palopo City. Furthermore, the caught skipjack fish is transferred to the marketing agent to be brought to the target consumers. The handling of fresh skipjack fish is done traditionally by giving ice as much as one third to one-quarter of the total weight of fish marketed. Furthermore, the activities of fish sellers are observed from the beginning of the landing until the end of the sale. Physical quality assessment is carried out starting from the fish landing location as the 0-hour assessment, the first sale as the 4-hour assessment, and the final sale as the 8-hour assessment.

2.3 Sample preparation

The samples fish used were randomly selected for measurement of temperature, pH, and organoleptic. Temperature is measured using a digital thermometer. Fish pH measurements were carried out based on the method conducted by Rayder (1985) using a pH meter.

2.3 Peroxide Value

Peroxide value (PV) is determined according to the method by Panpipat et al. [13]. The sample (2.0 g) was put into 25 ml mixture of organic solvents (chloroform: a mixture of acetic acid, 2: 3). The mixture is shaken vigorously, followed by adding 1 ml of saturated potassium iodide solution. The mixture is stored in dark conditions for 5 minutes, and 75 ml of distilled water is added, and the mixture is shaken. Next, the mixture was added 0.5 ml of starch solution (1%, b / v) as an indicator. Peroxide value was determined by titrating iodine released from potassium iodide with standardized sodium thiosulfate solution 0.01 N. PV expressed as milliequivalents of free iodine per 100 g lipids.

2.4 TVB

The total alkaline volatile nitrogen (TVB-N) content was determined using the Conway micro diffusion test, as explained by Panpipat et al. [13]. The sample (2 g) was added to 8 ml TCA 4% (b / v) and homogenized at a speed of 11,000 rpm for 2 minutes. Homogenate was centrifuged at 3,000 × g for 15 minutes at room temperature. The supernatant called sample extract (1 ml) is placed in the outer ring of the Conway device. The inner ring solution (1% boric acid containing the Conway indicator) is then channeled to the inner ring. To start the reaction, K_2CO_3 (1 ml) mixed with sample extract. The Conway Unit was closed and incubated at 37^{o}C for 60 minutes. The inner ring solution is then titrated with 0.02 N HCl until the green color turns pink.

2.5 Organoleptic assessment

The fish organoleptic assessment was carried out by score test using organoleptic score sheet for SNI-01-2729-1992 fish issued by the Directorate General of Fisheries in Jakarta 1994/1995 [14]. The rating scale ranges from 1 to 9, representing the lowest to the highest value.

2.6 Statistical analysis

The physical assessment data was collected and then statistically analyzed using SPSS ver.16 and evaluating ANOVA for data evaluation. Tukey test was used to compare the two groups as appropriate. A value of P <0.05 was considered statistically.

3. Result and Discussion

3.1 Effect of temperature on the quality of fish during the sale process in the market

The initial temperature when the fish landings for all fish landing areas are respectively (PT) Palopo City, (PB) Pare-Pare City, (PT) Sinjai Regency, and (PB) Makassar City, are 19.60, 19.89, 20.06, 20.23^{o}C respectively; then there was an increase in temperature to 24.01, 22.33, 23.47, 23.36^{o}C respectively for eight hours of selling fish to consumers (Table 1). The results showed that there was a temperature increase of 3-4^{o}C during the sale process in the market. The increase in temperature obtained in this study is low. In one study, it was reported that changes in temperature on fish fillets increased by an average of 3^{o}C per hour [15]. Temperature changes in fish very quickly in the first two hours when fish are associated with ambient temperature.

Fish sellers provide ice at the beginning of the fish sales process, which is a quarter of the total amount of fresh fish

stored in storage containers. Giving ice to fish when after catching is a common way to do other than using liquid ice and cold temperatures [15]. Ice utilization is done to prevent the decline in the freshness of the fish drastically. The cooling of fish with ice can produce low temperatures which can help prevent the process of autolysis and decomposition [16], inhibit the work of enzymes and chemical reactions in making changes that cause decay in fish [11].

Temperature significantly increases ($p < 0.05$) during the sales process were shown in all South Sulawesi regions including the WC, Pare-Pare City, and Makassar City, and on the EC namely Palopo City and Sinjai District (Table 1). We assume that the handling carried out is the same as giving the amount of ice in the storage container. The amount of ice is one indicator that determines the change in temperature of cooling fish. This study confirmed the amount of ice used by sellers of fresh skipjack in South Sulawesi, which is five times less than the predetermined standard of ice used for cooling fish. According to Huss [18] that to determine the use of various types of ice can be done based on particular volume (m^3 /ton), which is the use of as much as one ton of flake ice, ice blocks, and crushed ice blocks for volume 2.2-2.3, 1.08, and 1.4-1.5 m^3.

Table 1: Changes in the physicochemical characteristics of skipjack fish during sales in the capture area of South Sulawesi

Fish landing area moreover, storage time on ice (hours)	Characteristic of physic-chemical (mean±std.)			
	Temperature (°C)	pH	Peroxide value (mEq oxygen /g)	TVB (mg/100g)
WC Pare-Pare				
0	19.89±1.05[a]	6.0±0.0[a]	14.77±9.18 [a]	8.23±2.19 [a]
4	21.11±1.27[b]	5.3±0.5[b]	16.37±6.51 [a]	10.28±1.91 [a]
8	22.33±0.71[c]	5.0±0.0[c]	18.34±5.48 [a]	10.32±3.66 [a]
WC Makassar				
0	20.23±0.98[a]	6.2±0.16[a]	30.77±11.11 [a]	7.82±1.59 [a]
4	21.36±1.14[a]	5.9±0.13[b]	28.49±8.76 [a]	8.06±1.57 [a]
8	23.36±0.80[b]	5.7±0.06[c]	32.17±10.38 [a]	7.94±1.89 [a]
EC Palopo				
0	19.60±0.42[a]	6.09±0.07[a]	18.70±7.10 [a]	6.97±1.10 [a]
4	22.64±0.42[b]	5.77±0.08[b]	27.88±9.09 [ab]	7.72±1.10 [a]
8	24.01±0.82[c]	5.41±0.08[c]	35.11±12.76 [b]	9.22±1.49 [b]
EC Sinjai				
0	20.06±0.46[a]	6.11±0.08[a]	23.77±3.54 [a]	7.65±1.52 [a]
4	21.75±0.31[b]	5.74±0.20[b]	16.80±4.49 [ab]	7.74±1.54 [a]
8	23.47±0.42[c]	5.57±0.08[c]	19.47±4.65 [b]	9.29±1.63 [a]

Note: different superscripts in the same column show significant differences ($p<0.05$) in each different fishing area

Traditional handling by giving ice at the beginning of handling with little ice piles and without adding ice regularly increases the final temperature of the sale, both in the East Coast and West Coast catchment areas of 23.7 and 23.0°C, respectively (Figure 2). The study is in line with Margeirsson's [19] research that the traditional method for handling fresh fish carried out by storing fish in styrofoam, and four-layer ice stacks result in a higher temperature increase than the method of handling with 12 levels of ice stacks. Furthermore, other studies show that fish freshness is influenced by physical factors, including short storage times with low handling temperatures [20]. We indicate that the fewer stacks of ice and an extended shelf-life can cause a rise in temperature, which results in a decrease in the quality and freshness of the fish.

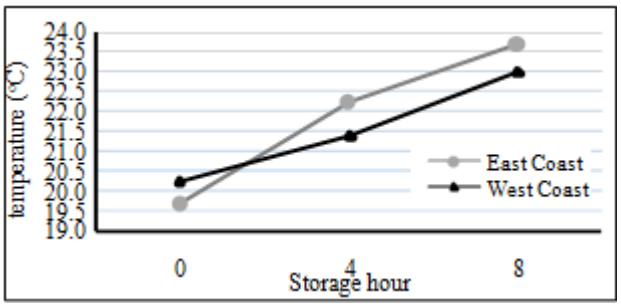

Figure 2: Change in temperature of skipjack fish stored ice on the EC and WC landed fish area in South Sulawesi

3.2 pH

The results showed that the initial pH value of the marketed skipjack tuna sold decreased significantly ($p < 0.5$) with the length of time of sale (Table 1.). The lowest pH value at the beginning of the sale process of fresh skipjack fish is (WC) Pare-Pare, (EC) Palopo, (EC) Sinjai, and (WC) Makassar, respectively 6.0, 6.09, 6.11, and 6.2. Furthermore, there was a decrease in pH at eight hours of sales, namely 5.0, 5.41, 5.57, and 5.7. One indicator of freshness and decay of fish is pH. The pH value for the indicator of fish freshness is neutral, namely 7. In the study, the pH of fresh skipjack fish has been reduced for eight hours of sales in the East Coast and West Coast regions, reaching 5.5 and 5.7 (Figure 3). We indicates that the handling of fish by providing ice (temperature drop) carried out by traders is still very lacking.

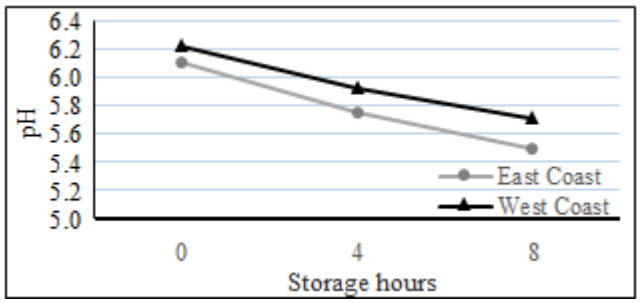

Figure 3: Change in pH of skipjack fish stored ice on the EC and WC landed fish area in South Sulawesi

The pH value at the beginning of the treatment is close to neutral, which indicates that the quality of fish meat is good shortly after being lowered from the ship to the landing site. Indicators of fish freshness are with pH above 6.3 [21] [12]. Furthermore, a decrease in fish pH to reach point 5.5 (Figure 3) occurs when the fish is brought to the traditional market and leads to the end of the sale, which reflects a decline in the quality of fresh fish at the end of the sale. The pH value is low due to the mechanism of hydrogen ion accumulation which is free from the destruction of the adenosine nucleotides and their metabolites in the fish muscle accompanied by lactate accumulation [22] [23]. However, other studies have shown that the pH of red meat fish such as mackerel and tuna tends to be low at 5.5-5.9 [24].

Furthermore, the diffusion of CO_2, the formation of carbonic acid, and stress in fish also cause a decrease in pH. The stress of fish caught can be produced from each fishing and fishing process before landing at the fish landing site. According to Maeda et al. [25] concluded that catching and removing catches can produce stress on fish, which results in decreased levels of ATP and lactic acid.
ATP levels are associated with energy available in the body of the fish and optimization of handling fish. According to Boopendranath & Hameed [26] that an important aspect that is responsible for the fishing process is the optimization of fish energy when captured. One of the energies for fishing operations is donated from ice brought to handle fish on board. However, purse seining from the research of Boopendranath & Hameed [26], shows that ice for preservation of fish on a ship cannot form part of the energy input. Energy needs by fish are used to be able to heal themselves from stress during the handling process so that the freshness of the fish can be maintained.

3.3 Peroxide value

The results showed that the peroxide rate in the West Coast sales area was the same ($p > 0.05$) during fish sales. Furthermore, fish sales in the East Coast area showed significant differences ($p < 0.05$) for the cities of Palopo and Sinjai at the end of the sale. The average value of peroxide numbers at the beginning of sales in the sequence are (WC) Pare-Pare, (EC) Palopo, (EC) Sinjai, and (WC) Makassar, namely 14.77, 18.70, 23.77, and 30.77 mEqoxygen/g (Table 1.). At the end of the sale there was an increase in peroxide numbers in the cities of Pare-Pare, Palopo City, and Makassar City, namely 18.34, 35.11, and 32.17 mEq oxygen /g respectively, but in the Sinjai area there was a decrease in peroxide figures at eight hours of sales of 19.47 mEq oxygen/g (Table 1).

In the study, peroxide numbers of fresh skipjack fish which, after being captured until sales for eight, were still suitable for consumption in all marketing areas in South Sulawesi, namely in Makassar, Pare-Pare, Palopo, and Sinjai. Fish meat with peroxide numbers above ten meq oxygen/kg shows fish meat that is not healthy for consumption [27], and peroxide figures 20-40 meq oxygen/kg shows rancid fish meat [28]. Furthermore, the peroxide value of skipjack meat obtained is lower than other fresh fish such as Bizz, Grass carp, Shabbout, Common carp, and Silver carp, which are 3.40, 4.47, 5.29, 7.25 and 8.86 meq oxygen/kg respectively [29], fresh fish in Africa (albacore and Claries angullaris) are 7.23 and 4.00 meqoxygen/kg [30][31]. This research confirms that small fat oxidation occurs in fresh skipjack fish during the front of the marketing hours and by handling using ice stacks. In other words, the initial decay of fresh fish can be minimized by controlling cold temperatures using ice with a long storage time of fish in ice under eight hours.

The peroxide numbers of fresh skipjack fish in the study on the West Coast showed fluctuations during the eight-hour market; namely the first four hours decreased and then increased at the end of marketing, while on the East Coast it was seen to increase until the end of sales (Figure 4).

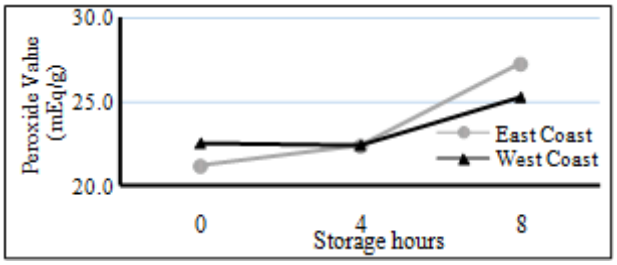

Figure 4: Change peroxide value of skipjack fish stored ice on the EC and WC landed fish area in South Sulawesi

Fluctuations in peroxide numbers are also shown in rainbow trout [33] [34]. This shows that achieving the highest concentration of unsaturated fat is different in each hour of sale and it is difficult to determine the standard peroxide against rancid odors. The high number of peroxide is an indicator of the occurrence of rancid fat, and vice versa the value of low peroxide is due to the depletion of peroxide after reaching the highest concentration, followed by an oxidation reaction widely [35] [36] [37]. Increased numbers of fresh fish peroxide during the storage period by the cooling method are shown in red mullet fish (*Mullus barbatus*) and fish of jackfruit seeds (*Upeneus moluccensis*) [38].

3.4 TVB

The lowest TVB values obtained from this study were Palopo City, Sinjai Regency, Makassar City, and Pare-Pare City, respectively 6.97, 7.65, 7.8, 8.23 mg / 100gr (Table 1). After eight hours of sale of skipjack fish in the market and directly to consumers the value of TVB increased in the Palopo, Sinjai, Pare-Pare areas, respectively 9.22, 9.29,

10.32 mg / 100gr. Furthermore, the value of TVB at the end of sales in Makassar City increased by 7.94 mg / 100gr. The results showed that TVB values until the end of sales were the same (p> 0.05) in Pare-Pare, Makassar, and Sinjai, but TVB values at eight hours of sales showed a significant difference (p <0.05) in Palopo city. The value of TVB for freshness of fish and fish products is grouped into four categories is very good, with 25.00 mg / 100g or smaller; suitable, containing 30.00 mg / 100g; can be sold, with 35.00 mg / 100g; decay, the TVB-N content above 35.00 mg / 100g (Kietzman et al., 1969; Alparslan et al., 2014). Fresh skipjack that is sold for eight hours is still limited to fish worthy of consumption and sale. This study shows the TVB value of fresh skipjack meat varies, although it is more likely to increase over eight hours of sales, both in the East Coast and West Coast landing areas (Figure 5). The TVB value in this study averaged under 12 mgN/100g, and did not show a significant increase.

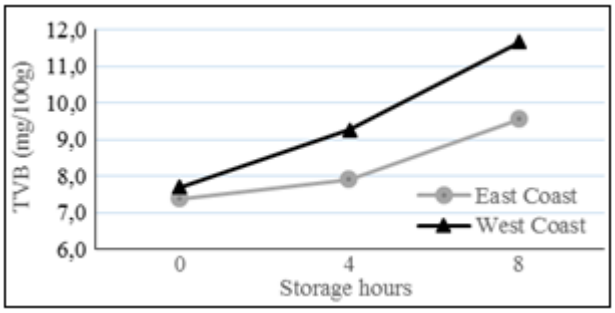

Figure 5: Change peroxide value of skipjack fish stored ice on the EC and WC landed fish area in South Sulawesi

TVB is a biochemical indicator of the process of fish meat decay. Some studies show TVB of fresh fish stored on ice and higher values of 12.4 mg TVB-N / 100 for eel [39], and 17.22 mgN/100 in European sea bass [40]. The fluctuations in TVB values obtained from the East Coast and West Coast landing areas indicate that the high and low TVB values are influenced by the methods of handling carried out by market participants, and temperature fluctuations. Changes in the value of TVB are suspected of washing nitrogen compounds when given ice packs at the beginning of the sale. This result is found in sea bass and sea bream gave liquid ice [41].

3.5 Organoleptic

The results showed that the organoleptic values of fresh skipjack fish were significantly different (p <0.05) during the sales process for all fishing areas (Table 1). Organoleptic values at the beginning of sales in a sequence are Makassar, Sinjai, Pare-Pare, and Palopo, were 8.2, 8.2, 8.1, 8.1. Furthermore, at the end of the sale, which is the eighth-hour assessment, the organoleptic values of all fishing areas have decreased in both the East Coast and West Coast regions 5.9 and 6.3 (Figure 6). In other words, fresh skipjack fish for up to four hours can be said to be still fresh, and after four hours, there is a decrease in the freshness of the fish.

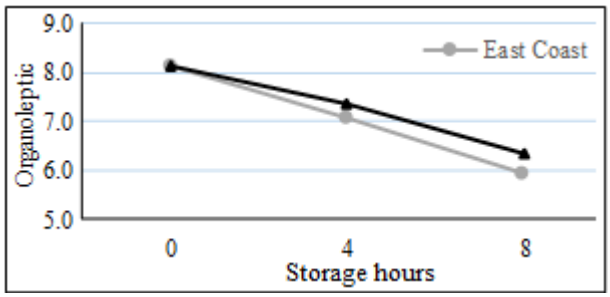

Figure 6: Change peroxide value of skipjack fish stored ice on the EC and WC landed fish area in South Sulawesi

The minimum meat freshness value needed for fresh fish criteria based on the Indonesian National Standard is ≥ 7 (Director General of Fisheries, 1995). Organoleptic values for fresh fish from several research results are 7.84 <μ <8.30 in milkfish [42], and 7.8 in tuna [43].

Sensor analysis is an analysis to measure organoleptic fish. The results showed that organoleptic fresh skipjack research generally tended to decrease along with the sales time of eight hours. Organoleptic at the beginning and end of sales, respectively 7.59-8.37 and 5.30-6.44. The organoleptic decline is suspected of lack of ice during transport to the market until the final sale process. According to Erkan [44] that sea bream stored in ice and by washing water shows a low decay rate that results from gills and abdominal cavity. The low quality of organoleptic is strongly influenced by rising temperatures [45].

4. Conclusion

The handling of fresh skipjack caught in the West Coast and East Coast regions of South Sulawesi is done simply by giving ice at the beginning of the sale for eight hours, resulting in a decrease in the freshness of the fish. This is known from the physicochemical characteristics, showed that there was a decrease in the quality of skipjack fish due to an increase in temperature of 3-4^{o}C, a decrease in pH reaching 5.0-5.7, an increase in the peroxide number of 25.3-27.3 mEqoxygen/g and an increase in TVB 9.3-12.0 mg/100, and a decrease organoleptic value 5.9-6.3 at the end of the sale. Even so, fresh skipjack is still categorized as suitable for consumption and sale.

5. Acknowledgment

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