Fish quality and nutritional assessment of yellowfin tuna (Thunnus albacares) during low temperature storage

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Abstract. Assessment of fish freshness is the most important and frequently difficult to determine. Moreover, fish spoilage generally depends on the temperature to control the bacterial and the autolytic development. This research was aimed to determine the quality of yellowfin tuna and skipjack tuna using physical, sensory, microbiology and chemical methods as well as their nutritional quality during certain time of freezing temperatures storage. Methods applied in this study were: organoleptic test with semi-trained panelist, pH, TPC and TVB determination monthly during 6 months of storage. Nutritional values were determined by the variation of their amino acid and lipid profiles. The results indicated that the pre-rigor phase was happened during storage until the 3rd month. In the 4th month of storage to the last month the fish samples were in the phase of rigor mortis. Organoleptic and pH value trends were decreased while the value of TPC and TVB were increased during 6 months freezing temperatures. In conclusion, during 6 months low temperature storage, the freshness quality of yellowfin and skipjack tuna as well as their nutritional value were decreased. Thus, there was fixed correlation between pH, TVB, TPC, organoleptic and nutritional values with fish freshness quality.

Keywords: amino acid, lipid, organoleptic, pH, TVB

1. Introduction

Indonesia's fishery product processing sector has been growing to meet domestic and foreign demands. Consumer demand for consumed fishery products increased every year. It is reported in 2015, fish consumption in Indonesia reached 41.11 kg/capita/year, in 2016 reached 43.94 kg/capita/year and in 2017 reached 46.49 kg/capita/year. The main fisheries commodity for export are scombridae fish and demand by from various countries worldwide (KKP 2018). Tuna is an important economical fish belong to scombridae
families with high nutritional content and high commercial value. The high demand for tuna commodities has made a great opportunity for Indonesia as a producer to export in the form of fresh, frozen and processed products. Statistical data showed the value of exports of scombridae fish species such as tuna, little tuna and skipjack in 2016-2017 increased by 16.7% (KKP 2017).

Fish is an important source of nutrition for humans because it contains high-quality protein, vitamins, and omega-3 fatty acids, particularly which found in pelagic fish (Gang 2013). The quality of fish is related to the characteristics and conditions of their raw materials (Valtysdottir et al 2010). The quality of fish is related to the level of freshness of the fish. The quality of fish freshness can change through enzymatically, microbiologically, chemically, and physically processes (Nurilmala et al 2018). Fish quality deterioration is strongly influenced by temperature and storage time. A solution to inhibit fish quality deterioration was by providing certain treatments such as storage in low temperatures (Husni and Putra 2014).

Matutina (2018) explained that longtail tuna stored for 7 days in chilling temperature experienced an organoleptic decreasing value. While the pH value of longtail tuna reached 5.35 with TVB value 21.15 mgN/100 g and microbial total was 6.23 log CFU/g. Sormin et al (2016) reported that the pH value of tuna in the rigor mortis phase decreased into 5.4. Al-Busaidi et al (2017) stated that the TVB value of tuna after stored at 8°C for 9 days was 21.99 mgN/100 g. Marada (2012) reported that skipjack tuna stored at freezing temperatures for 20 days had microbial total of 4.59 log CFU/g. Appropriate handling of fish at low temperature can inhibit the growth rate of spoilage bacteria. Another critical factor that must be taken into account when handling the fish at low temperature is temperature fluctuations that must be considered (Husni and Putra 2014). Furthermore, longer period of frozen storage may cause quality changes in tuna and skipjack. This study was aimed to determine the quality of yellowfin tuna and skipjack tuna using physical, sensory, microbiology and chemical method as well as their nutritional quality during certain time of freezing temperatures storage.

2. Materials and methods

2.1. Materials

The main raw material used in this study is yellowfin tuna obtained from Binuangune Waters, Tanjung Lesung, Banten. The chemicals used in this research were distilled water, physiological saline solution, agar plate count media (PCA), TCA 7%, K2CO3, boric acid solution (H3BO3), 0.011 N HCl, carrez reagent, sodium carbonate, solution and benzyl chloride, methylamine hydrochloride, retinol palmitate, glacial acetic acid, HPLC grade methanol, 95% ethanol, tetrahydrofuran, THF, KOH solution, methanol chromatography, acetonometry, trimethylamine, phosphoric acid, NaOH, methanol, n-hexane, isopropanol, ethanol, absolute, ascorbic acid, methanol chromatography, acetonometry, trimethylamine, phosphoric acid, NaOH, methanol, n-hexane, isopropanol, ethanol, absolute, ascorbic acid, methanol chromatography, acetonometry, trimethylamine, phosphoric acid, NaOH, methanol, n-hexane, isopropanol, ethanol, absolute, ascorbic acid, methanol chromatography, acetonometry, trimethylamine, phosphoric acid, NaOH, methanol, n-hexane, isopropanol, ethanol, absolute, ascorbic acid, methanol KOH, nitric acid (65% HNO3), perchloric acid (HClO4 70%), concentrated H2SO4, BF3, saturated NaCl, n-hexane, and anhydrous Na2SO4.

The equipments used in this research were cool box, fresh fish organoleptic score sheet based on SNI 2729: 2013, homogenizer, micropipette, tip, test tube, petri dish, vortex, incubator, autoclave, pH meter, filter paper, conway plate, gas chromatography (gas chromatography (Shimadzu GC 2010 Plus, Japan), Atomic Absorption Spectrophotometer (AAS) (Shimadzu, Japan), UV-200-RS spectrophotometer, High Performance Liquid Chromatography (HPLC) (Shimadzu RF 20A, Japan).
2.2. Research method

2.2.1. Sample Preparation. Tuna samples were 18 individuals with average size of 37 cm and weight of 700 g. Landed tuna were put in a cooled box without gutting and put with slurry ice before transported to the laboratory. The storage temperature was -20°C±2°C. Samples were stored and observed for 6 months and tested at month 1 (B1), month 3 (B3), and month 5 (B5). For each observation, 6 individuals of tuna were used.

2.2.2. Physical analysis. Morphometric measurements were done to assure the tuna weights and sizes. The parameters for morphometric measurements were total weight, total length, standard length, fork length, height, and width of fish. The proportion of tuna body parts were done in fresh conditions including meat, bones, viscera, and skin.

2.2.3. Organoleptic analysis. Organoleptic testing of tuna in this study was conducted with reference to SNI 2729: 2013 concerning fresh fish (BSN 2013). The parameters observed in organoleptic testing were appearance in the form of eyes, gills, and mucus on the surface of the body, flesh, odor, and texture. Analysis of fish freshness with data obtained from the assessment of fresh fish has the values between 7-9, less fresh fish with a value of 4-6, and not fresh fish with a value of 1-3.

2.2.4. Microbiology and chemical analysis. Microbial analysis in this study included Total Plate Count (TPC) (Fardiaz 1993). Chemical analysis in this study includes proximate analysis (AOAC 2005), acidity (pH) analysis, Total Volatile Base (TVB) (Apriyantono et al 1989).

2.2.5. Nutritional analysis. Amino acid analysis (AOAC 2005), taurine analysis (AOAC 2005), mineral analysis (AOAC 2005), fatty acid analysis (AOAC 2005), vitamins A, B6, D analysis (AOAC 2005) and mineral analysis of Na, Mg, K, Fe, Ca (AOAC 2005).

2.2.6. Data Analysis. Data analysis in this study was carried out using a completely randomized design (CRD) (Steel and Torie 1993). The influencing factor in this study was the difference of fish storage time measured in triplicate. Data were analyzed statistically by analysis of variance (ANOVA).

3. Results and discussion

3.1. Morphometric of yellowfin tuna
Yellowfin tuna is one of pelagic fishes. Morphometrics of yellowfin tuna (Thunnus albacares) can be seen in figure 1.

![Figure 1. Morphometric of yellowfin tuna (Thunnus albacares).](image)
Morphometrics of yellowfin tuna in this study obtained an average value of total weight of 712±152.21 g, total length of 37.76±2.72 cm, standard length 29.87±2.18 cm, and fork length of 33.82±2.43 cm. Burhanis et al (2018) mentioned in their study, the standard length of yellow fin tuna ranged from 35-105 cm and the differences in tuna length size are caused by genetic changes and migration processes in searching for food and spawning. The length of the yellow fin tuna is 50-60 cm with ages 12 to 15 months and the total length of 120 cm reaches sexual maturity (Collete and Nauen 1983). Based on the research of Nurjanah et al (2015), morphometric measurements of skipjack were about 30.05 cm for total length, 24.65 cm for standard length, 28.30 cm forked length, 7.10 cm height, 4.90 cm body width, and the weight was around 424.67 g.

3.2. Body proportion of yellowfin tuna
The proportion of the body parts of yellowfin tuna in fresh condition was meat 57.92%, bone 30.23%, viscera 7.65%, and skin 4.21%. The most widely used fish body part is the meat part. Another use of fish body part is that fish viscera can be used in making protein hydrolyzate (Nurhayati et al 2014), fish bones can be used as ingredients in the production of hydroxyapatite (Bin et al 2013), fish skin, especially yellow fin tuna skin can be used as gelatin (Nurilmala et al 2017).

3.3. Organoleptic value of yellowfin tuna
Organoleptic values for the eye in sample B1 were 7-8 indicating that the appearance of yellowfin tuna was still fresh. The eye was of flat eyeballs, clear corneas and pupils, not too shiny and of fish specific colour. Organoleptic values for the gill during six month storage were 7-8 indicated by dark red or reddish-brown gills. Organoleptic values of the mucus in the first month to the sixth month had values 7-8. This showed that the mucus parameters of yellowfin tuna were still fresh, which means that the mucus layer was clear, transparent, and quite bright (BSN 2013).

Organoleptic values of the meat in the 1st to 6th months had 7-8. This showed that yellowfin tuna meat was still in a fresh condition and suitable for consumption, which means that the meat incision was still bright, specific type and strong meat network. The organoleptic values of the odour in the 1st to 6th months had 7-8. This shows that the yellowfin tuna were still fresh (BSN 2013).

Organoleptic values of the texture in the 1st to 6th months had 7-8. This showed the texture parameters of yellowfin tuna fish are still fresh, which means the texture of the fish is still in a solid, compact, and elastic state (BSN 2013). Dawson et al (2018) reported that changes in texture during frozen storage are related to protein denaturation in fish.

3.4. pH values of yellowfin tuna
The storage time at freezing temperatures affected pH of the meat (figure 2). The pH value of yellowfin tuna decreased in the 1st to 6th month. Silbande et al (2016) stated that the pH value of yellowfin tuna increased in freezing temperatures by 5.77-5.97, this result is different from the results of the study. Mateo et al (2006) explained that in post mortem condition, fish produces anaerobic metabolism which causes a rapid decrease in the pH value of meat due to high lactic acid production.
Figure 2. pH of yellowfin tuna.

3.5. **Plate count of yellowfin tuna**

The results showed that the storage time at freezing temperatures affected the plate count values (figure 3). The average plate count value of yellowfin tuna increased during storage. Plate count value in fresh fish is at most 5.70 log CFU/g (BSN 2013). Silbande *et al* (2016) stated that the plate count value in tuna during frozen storage was 3.5 log CFU/g.

Figure 3. Plate count of yellowfin tuna.

3.6. **Total Volatile Base (TVB) of yellowfin tuna**

The storage time at freezing temperatures affected the TVB (figure 4). TVB value of yellowfin tuna increased during storage. The TVB values of the yellowfin tuna were still within the acceptance limit of fish for consumption (Farber 1965). Ekasari *et al* (2017) stated that the increase in the value of TVB is due to the presence of autolysis and the activity of spoilage bacteria during storage.
Figure 4. TVB value of yellowfin tuna.

3.7. Chemical composition of yellowfin tuna

Chemical composition analysis is used to determine the nutritional content of the ingredients. Analysis of the chemical composition of yellowfin tuna was done at the initial storage (B1) and final storage at the 6th month (B5). The chemical composition of yellowfin tuna is shown in table 1.

| Parameter | Storage period | First month (B1) | Sixth month (B6) | Fresh | Skipjack |
|-----------|----------------|------------------|------------------|-------|----------|
| Moisture  |                | 72.33±0.59a      | 72.97±0.08a      | 71.73 | 71.76    |
| Ash       |                | 0.60±0.07a       | 2.38±0.04b       | 1.48  | 25.29    |
| Lipid     |                | 1.21±0.04b       | 0.93±0.01a       | 0.51  | 0.60     |
| Protein   |                | 25.86±0.01b      | 21.47±0.04a      | 28.34 | 1.49     |

1Hadinoto and Idrus (2018), 2Nurjanah et al (2015)

The frozen storage treatment did not significantly affect the moisture of yellowfin tuna (p>0.05). Waleed and Hawarry (2012) state that the water content in food ingredients determines the acceptability, freshness and storability of the material. The yellowfin tuna frozen for six months had higher ash content than the initial storage. T-test results showed that frozen storage treatment significantly affected the ash content of yellowfin tuna (p<0.05). Hadinoto and Idrus (2018) in their study said the ash content of yellowfin tuna was 1.48%. Ash content contained in fish bodies is influenced by mineral content found in live fish habitat (Suwandi et al 2014). The high level of ash content at the end of frozen storage can be caused by the still presence of non-combustible mineral content such as Na, Ca, and P (Landeng et al 2017). The storage also affected the lipid and protein content. Hadinoto and Idrus (2018) in their study said the lipid content of yellowfin tuna was 0.51%. Kusuma et al (2017) stated that lipid content dropped during the process and frozen storage due to loss of triglyceride fraction caused by lipid oxidation. Hadinoto and Idrus (2018) in their research explained that the protein content of yellowfin tuna was 28.34%. The decrease in protein in food products stored at freezing temperatures can be caused by protein denaturation as a result of increased ionic bonds in intracellular tissue followed by water migration to extracellular tissue (Kusuma et al 2017).
3.8. Amino acid composition
The yellowfin tuna contained high amount of leusina and lysine. These results were consistent with research conducted by Peng et al (2013) stating the highest amino acids in yellowfin tuna are leucine and lysine. Storage at freezing temperature significantly affected the level of amino acid leucine and lysine (p<0.05). Moreover the yellowfin tuna also contained high level of glutamic acid and aspartic acid representing non essential amino acid. Peng et al (2013) explained that the amino acid glutamic and proline are high in yellowfin tuna. These amino acids content were also affected by storage period (p<0.05).

3.9. Fatty acid composition
The results of the analysis of fatty acids showed that yellowfin tuna contained high levels of polyunsaturated fatty acids (PUFA). The highest polyunsaturated fatty acid (PUFA) in the sample was omega-3 fatty acids. Yellowfin tuna stored at freezing for six months had a DHA level of 9.5% lower than before the 11.5% frozen storage treatment. Decrease in average fatty acid levels during 6 months frozen storage by 24.48%. ANOVA test results showed that frozen storage treatment significantly affected levels of palmitic, oleic, and omega 3 fatty acids in yellowfin tuna (p<0.05). The more double bonds of fatty acids contained, the more unstable it can break easily and cause the fatty acid content in a food product to decrease. Frozen storage can reduce the reduction of fatty acids in a food product (Handayani et al 2014).

3.10. Taurine composition
Taurine level in yellowfin tuna decreased from 434.43 mg/100 g at intial storage to 168.48 mg/100 g in the third month and decreased again to 113.63 mg/100 g in the fifth month. ANOVA test results showed that frozen storage treatment significantly affected the composition of yellowfin tuna taurine (p<0.05). The results obtained was not much different from the results of the study of Peng et al (2013) which showed taurine levels of yellowfin tuna of 176 mg/100 g. A decrease in taurine levels during frozen storage is thought to be correlated with the decrease in the amino acids methionine and cysteine. Elvevoll et al (2006) explain that taurine has a correlation with the amino acids cysteine and methionine because taurine is synthesized from the essential amino acid methionine through cysteine. The average decrease in taurine levels during 6-month freeze storage was 73%. Taurine is a powerful antioxidant that can prevent DNA damage at low concentrations. Based on studies reported that taurine can prevent diabetes and liver fibrosis through its antioxidant mechanism (Tasci et al 2007).

3.11. Mineral composition
Yellowfin tuna stored at freezing for six months had calcium composition of 60.98±0.56 mg/kg, sodium of 4.54±0.45 mg/kg, magnesium of 1.33±0.01 mg/kg, potassium at 14.77±0.16 mg/kg and iron at 2.08±0.21 mg/kg. Gokoglu et al (2004) in their research explained that rainbow trout had calcium levels of 63.2 mg/kg, sodium of 4.55 mg/kg, magnesium of 2.09 mg/kg, potassium of 30.62 mg/kg and iron of 2.01 mg/kg.

Nurjanah et al (2012a) found sea leeches (Discodoris sp.) contained high level of calcium, magnesium, and zinc. Instead the potential mineral source in aquatic products is golden snail eggs with the following results: calcium 17,925.18 ppm, sodium 402.92 ppm, potassium 252.02 ppm, phosphorus 197.28 ppm, and magnesium 112.29 ppm (Nurjanah et al 2019). Mineral contents of cuttlefish namely: sodium, phosphorus, potassium and calcium, with sodium content being the highest (1532.7-1610.4 mg/kg). Zinc and copper were the dominant trace minerals in both portions (Nurjanah et al 2012b).
3.12. Vitamin composition

The vitamins analyzed were vitamin A, vitamin B6, and vitamin D. The composition of the vitamins yellowfin tuna is presented in table 2.

| Vitamin Type       | Treatment                  | First storage (B1) | Last Storage (B6) | Fresh Tuna* |
|--------------------|----------------------------|--------------------|-------------------|-------------|
| Vitamin A (IU/100 g) | 115±0.00 b                  | <0.5±0.00 a        | 36.66             |
| Vitamin B6 (mg/kg)  | <0.2±0.00 a                 | <0.2±0.00 a        | 2.48              |
| Vitamin D (μg/100 g) | <0.3±0.00 a                 | <0.3±0.00 a        | 0.97              |

*Dias et al (2003)

Yellowfin tuna that was frozen for six months had lower vitamin A levels than the initial storage at freezing temperatures. The frozen storage significantly affected the levels of vitamin A but did not significantly affect the levels of vitamin B6 and D of yellowfin tuna. Dias et al (2003) in their research explained that the vitamin content of tuna was 36.66 IU/100 g. The decrease in vitamin A levels is due to the high amount of hydroperoxide in frozen meat tissue which is stable at low temperatures and oxidizes the vitamin (Dobreva et al 2013).

4. Conclusion

Six month storage at freezing temperature changed the quality and nutritional values of yellowfin tuna. The organoleptic and pH values decreased while TVB and plate count values increased. Nevertheless the yellowfin tuna was still considered in fresh condition. The highest essential amino acids were leucine and lysine while the non-essential amino acids were glutamic acid and aspartic acid. Yellowfin tuna contained high levels of polyunsaturated fatty acids. Taurine was decreased during storage. The highest mineral content was calcium at 60.98±0.56 mg/kg. Yellowfin tuna had shown lower vitamin A level than the initial condition before storage.

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