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Quality Analysis of the Marketed Nile Tilapia *(Oreochromis niloticus)* in the City of Makassar, South Sulawesi

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ABSTRACT

Indonesia experienced a 23% increase in tilapia production, which is the highest production of aquatic products compared to other freshwater fishery commodities. Based on data on the production of superior aquaculture commodities in South Sulawesi Province in 2021, Makassar City produced 210.5 tons of tilapia. However, tilapia *(O. niloticus)* is a highly perishable food and spoils if not handled and stored properly. Fish freshness is one of the main factors in determining the price of fish. Tilapias sold in the market are generally placed on a container or desk at room temperature. Maintaining the freshness of fish is essential to preserve its economic and nutritional value. This quality deterioration can be determined by physical and chemical testing in the laboratory. Therefore, this study aimed to analyze the quality of tilapia fish marketed in Makassar City, South Sulawesi. The method used in this study was experimental, involving the collection of tilapia (*O. niloticus*) samples sold in Makassar City. Several test parameters were analyzed, including organoleptic properties, temperature, and chemical factors (pH, TVB, and peroxide number). The results of the TVB test indicated that the fish was not fresh and unsuitable for consumption after 24 hours of storage. However, during the 0–16 hour storage period, the fish remained fresh and suitable for consumption. Tests on pH, peroxide number, organoleptic properties, and temperature, conducted over 24 hours of storage with an ice-to-fish ratio of 2:1 (kg), confirmed that the tilapia marketed at Daya Traditional Market maintained its freshness and good quality.

INTRODUCTION

Tilapia is one of the fishery commodities favored by the community in meeting animal protein needs because it has thick meat and good taste **(Penarubia *et al.*, 2023)**. Indonesia experienced a 23% increase in tilapia production, which is the highest production of aquatic products compared to other freshwater fishery commodities **(Puspitasari *et al.*, 2022)**. Tilapia has the potential to be cultivated because it is able to adapt to environmental conditions with a wide salinity range **(Rahman *et al.*, 2021)**.

Based on data on the production of superior aquaculture commodities in South Sulawesi Province in 2021, Makassar City produced 210.5 tons of tilapia.

Tilapia is favored by many people because the meat is quite thick and tastes delicious, and the protein content is high so that it can be used as a source of protein **(Susanti *et al.*, 2021)**. Tilapia has a better nutritional content when compared to other freshwater fish such as the catfish **(Abdullah *et al.*, 2020)**. Tilapia protein content is 43.76%, fat is 7.01%, and ash content is 6.80% per 100 grams of fish weight **(Safitri *et al.*, 2023)**. According to **Ladja *et al.* (2020)**, tilapia *(O. niloticus)* is one of the perishable foodstuffs, meaning that it quickly deteriorates and spoils if not handled and stored properly. Factors affecting tilapia deterioration and spoilage include temperature, humidity, microbial contamination, and post-capture handling **(Rathnayaka *et al.*, 2021)**. Fish freshness is one of the main factors in determining the price of fish **(Puspitasari *et al.*, 2022)**. Fish deterioration begins when fish are caught or die **(Duarte *et al.*, 2020)**. Tilapia sold in the market is generally placed on a container or desk at room temperature. Fish must be sold out within 12 hours, so relatively few fish are sold with little profit **(Nurjanah *et al.*, 2004)**. This is due to the rapid deterioration of the fish. Maintaining fish freshness is crucial for preserving its economic and nutritional value **(Grema *et al.*, 2020)**. This ensures that the fish can be sold and consumed safely, without concerns about health risks.

Fresh fish is prone to quality deterioration due to enzymatic and bacterial activity **(Naeem *et al*., 2021)**. These processes break down the components of fish body tissue, leading to physical changes, such as softening of the fish flesh, and chemical changes that produce volatile, foul-smelling compounds **(Siegers *et al.*, 2022)**. These volatile compounds give the impression that the fish has spoiled, making their levels a useful indicator of fish quality deterioration **(Esteves *et al.*, 2021)**. This deterioration can be assessed through physical and chemical testing in the laboratory **(Ahmad *et al*., 2024)**. Therefore, this study aimed to analyze the quality of tilapia marketed in Makassar City, South Sulawesi.

MATERIALS AND METHODS

This research was conducted in October-November 2021 by taking 20 tilapia *(O. niloticus)* samples marketed at the Makassar Daya Traditional Market. The method used in sampling is the accidental sampling method. The sample has a relatively uniform size with an average length of 21cm and a weight of 190 grams. This research used an experimental method with several test parameters, namely organoleptic, temperature, and chemical (pH, TVB, and peroxide number). The research was conducted at the Laboratory of the Fishery Product Quality Implementation Center (BPMPP) of the Marine and Fisheries Service of South Sulawesi Province and the Feed Chemistry Laboratory of the Faculty of Animal Husbandry, Hasanuddin University.

Tilapia samples in this study were collected from a single trader at the Makassar Daya Traditional Market. The samples, purchased at 7:30 AM, were stored in an ice-filled container for approximately 30 minutes. At 08:00 AM, the first set of samples (0 hours) was taken for testing. One sample was tested for TVB parameters, one for organoleptic properties, one for peroxide number, one for pH, and one for temperature. For each sample, the length and weight were measured, and the samples were then placed in labeled zipper plastic bags before being stored in an empty cool box and transported to the laboratory for analysis.

Samples stored for 8 hours (collected at 16:00) and 16 hours (collected at 00:00) were treated in the same manner due to limited testing time, and were stored in the freezer. The following day, after similar treatments for the 24-hour storage samples (collected at 08:00), all samples were taken to the laboratory for testing using the designated parameters.

RESULTS

1. Organoleptic

Organoleptic testing is a testing method using human senses as the main tool to assess the quality of live fish and fresh fishery products. A scoring test is a test method for determining the quality level based on a scale of number 1 as the lowest value and number 9 as the highest value using a scoring sheet, with the limit of fresh fish quality requirements at a value of 7 **(SNI 01-2346-2006)**.

Table 1. Tilapia organoleptic test results

Storage time (Hours)	Organoleptic
0	9,0
8	8,5
16	8,0
24	7,5

Table (1) shows the mean organoleptic value of tilapia at 0 hours was 9.0 and decreased to 7.5 at 24 hours of storage. This shows that the average organoleptic value obtained decreases every hour.

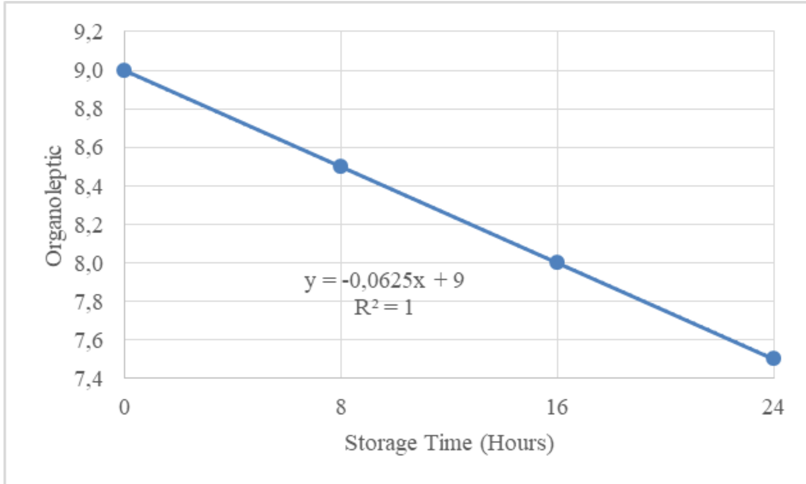

Fig. 1. Graph of organoleptic changes in tilapia

The results of the regression analysis of the relationship between storage duration and organoleptic value resulted in the equation y = 0.0625x + 9 with a correlation coefficient of R = 1.000 and a coefficient of determination of $R^2 = 1$.

2. Temperature

Temperature measurements of the tilapia were taken using a thermometer, which was inserted into the flesh until it reached the fish's thermal equilibrium. The thermometer was left in place for approximately 30 seconds, allowing the temperature reading to stabilize.

Table 2. Tilapia temperature test results

Storage Time (Hours)	Temperature (°C)
0	11,20
8	14,70
16	15,61
24	16,70

The average temperature value of tilapia at 0 hour was 11.2°C and increased to 16.7°C at 24 hours of storage. This demonstrates that the obtained average temperature value is rising every hour. After 24 hours of storage, the average value is at its maximum.

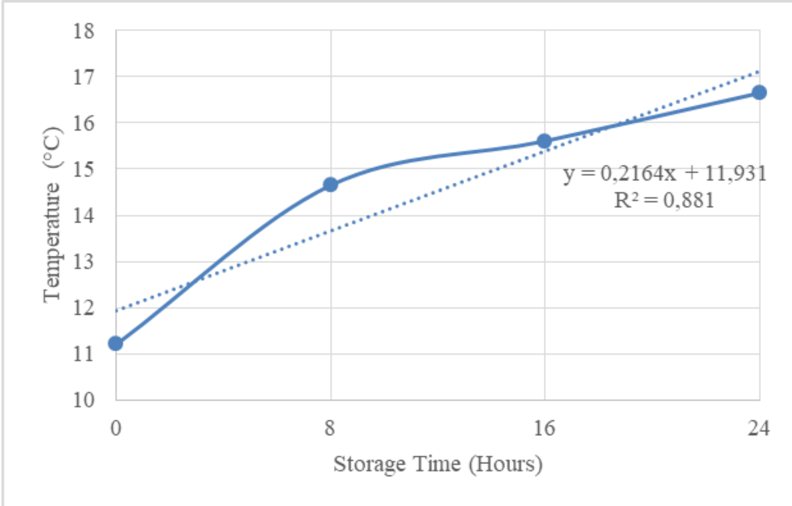

Fig. 2. Graph of temperature changes in tilapia

The equation obtained is y = 0.2164x + 11.931 with a correlation coefficient of R = 0.939, which means that the length of storage and temperature have a positive relationship; the longer the storage time, the higher the temperature value will also increase. The coefficient of determination R^2 = 0.881 means that 88.1% of the storage duration affects the temperature value.

3. Power of hydrogen (pH)

One measure used to assess the freshness of fish is pH. The pH value of fresh fish was in the range of below neutral to neutral pH. Table (3) shows the pH changes in the tilapia.

Table 3. Tilapia pH test results

Storage Time (Hours)	pH
0	6,7
8	6,5
16	6,3
24	6,2

The average pH value of tilapia in Table (3) shows that during 0 hour storage the pH value was 6.7 and decreased to 6.2 at 24 hour storage. This shows that the average pH obtained decreases every hour.

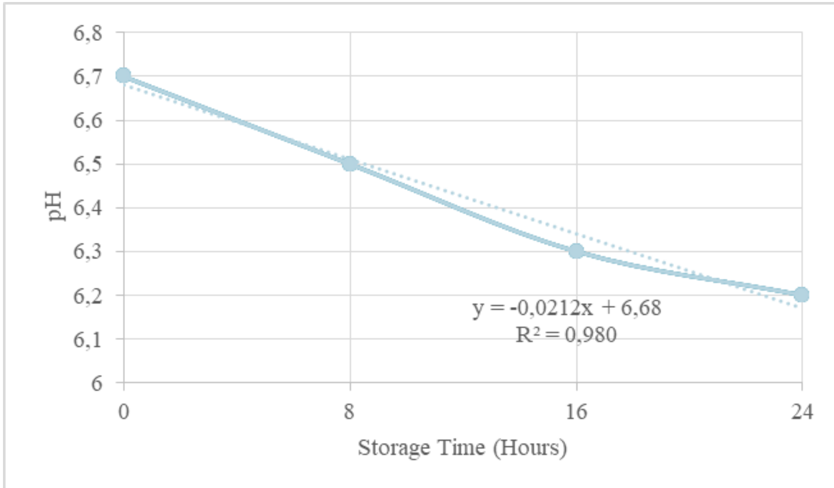

Fig. 3. Graph of pH changes in tilapia

The results of the regression analysis of the relationship between storage duration and pH value resulted in the equation y = 0.0212x + 6.68 with a correlation coefficient of R = 0.990 and a coefficient of determination of R^2 = 0.980.

4. Total volatile base (TVB)

Total volatile base (TVB) is one of the chemical parameters used to measure the freshness of fish, including tilapia. TVB measures the total amount of volatile base compounds, such as ammonia, trimethylamine (TMA), and dimethylamine (DMA), resulting from the decomposition of fish proteins by enzymes and bacteria during storage.

Table 4. Tilapia TVB test results

Storage time (Hours)	TVB (mg N/100g)
0	9,73
8	11,86
16	13,47
24	31,39

Table (4) illustrates that the average TVB value of tilapia fish increased after being stored for 24 hours, with the highest value being 31.39mg N/100g. The TVB value increases with the length of storage.

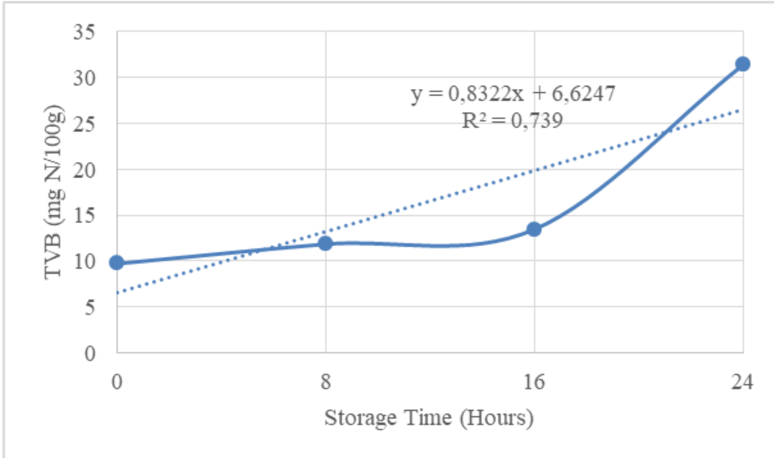

Fig. 4. Graph of changes in TVB value in tilapia

The results of the regression analysis of the relationship between storage duration and TVB levels resulted in the equation y = 0.8322x + 6.6247 with a correlation coefficient value of R = 0.86 and a coefficient of determination value of R2 = 0.739.

5. Peroxide number

The peroxide number is a measurement of the concentration of peroxide in fish fat, which is the initial product of fat oxidation. This is important as fat oxidation can cause rancidity and flavor changes in fish.

Table 5. Tilapia peroxide number test results

Storage time (Hours)	Peroxide number (mEg/kg)
0	2,57
8	5,53
16	11,73
24	15,57

The average value of tilapia peroxide number at 0 hour was 2.54 mEq/kg, and the average value at 24 hours was 15.57 mEq/kg. This shows that the average peroxide number value obtained is increasing every hour, with the highest average value being at a storage time of 24 hours.

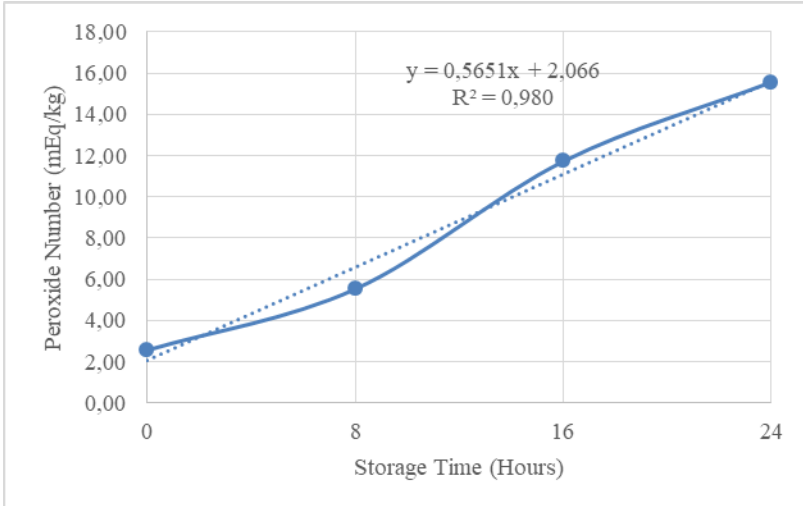

Fig. 5. Graph of changes in peroxide number values in tilapia

The results of the regression analysis of the relationship between storage time and peroxide number resulted in the equation y = 0.5651x + 2.066 with a correlation coefficient value of R = 0.990 and a coefficient of determination value of R^2 = 0.980.

DISCUSSION

1. Organoleptic

Organoleptic quality testing is subjective, as it relies on panelists' direct observations, which are recorded using a score sheet with a defined value range. According to SNI 2729: 2013, fish with organoleptic values between 5 and 6 are classified as "slightly fresh," while those with values between 7 and 9 are considered "fresh." The organoleptic test involves observing the fish's eyes, gills, mucus, odor, and the flexibility of the flesh. The value assigned corresponds to the characteristics listed on the score sheet; the higher the organoleptic value, the fresher the fish **(Prasetyo *et al.*, 2024)**.

The organoleptic values obtained in this study showed a decline, which is typical. As **Santhi (2017)** notes, once the organoleptic value of fish decreases, it cannot be restored, as these values can only be maintained through proper handling. Over 24 hours of storage, the average organoleptic value ranged from 7.5 to 9.0, indicating that the fish remained in the "fresh" category. This aligns with the statement of **Kitosan *et al*. (2014)**, who observed that organoleptic values decrease over time due to physical, chemical, and microbiological changes. These findings suggest that tilapia sold at Daya Traditional Market, when stored on ice for 24 hours, remains suitable for consumption. This complies with the safe consumption limits for fresh fish set by **SNI (01-2346-2006)**.

2. Temperature

In this study, the results obtained are y = 0.2164x + 11.931 with a correlation coefficient of R = 0.939, which means that the length of storage and temperature have a positive relationship; the longer the storage time, the temperature value will also increase. The coefficient of determination R^2=0.881 means that 88.1% of storage time affects the temperature value. Temperature and time parameters have a relationship that causes the process of deterioration of fish quality. Low ambient temperature will prolong the freshness of the fish **(Husain & Musa, 2021)**.

The use of low temperatures in the form of refrigeration can slow down the biochemical processes that take place in the fish body, which leads to the deterioration of fish quality. At low temperatures, chemical and enzymatic decay activities can be slowed down **(Rohmah *et al.*, 2022)**. Some bacteria that can accelerate the deterioration of fish quality can be inhibited using low temperatures in the range of 0-45°C **(Mugwanya *et al.*, 2022)**.

3. Power of Hydrogen (pH)

Table (3) shows that the average value of the pH measurement results in tilapia during 24-hour storage is in the range of 6.2-6.7, indicating that the fish is still suitable for consumption. According to **Nami *et al.* (2024)**, the pH of fresh fish meat is in the range below neutral to neutral pH; the pH value for live fish is around 7.0, and after the fish dies, the pH decreases to 5.8-6.2, then rises again toward alkaline during low-temperature storage. This is related to the availability of glycogen reserves in the meat. If the glycogen reserves have been completely decomposed, the pH of the meat will stop decreasing **(Leiwakabessy *et al.*, 2024)**. The decomposition of protein and components other than protein containing nitrogen during the quality deterioration process will increase the pH of fish meat, and the higher the level of foaming, the higher the pH. Rotten fish has a pH of about 10-11 **(Suharto *et al.*, 2024)**.

The decrease in pH occurs because when new fish die there is a decrease in ATP and keratin phosphate through the active process of glycolysis, where glycolysis converts glycogen into lactic acid, which causes a decrease in pH **(Remesar & Alemany, 2020)**. Meanwhile, the increase in pH value indicates the growth activity of putrefactive bacteria by the action of a number of enzymes in fish tissue that produce ammonia **(Herawati *et al.*, 2020)**. In this study, the results showed that the length of storage and pH have a negative relationship; the longer the storage time, the pH value will also decrease.

4. Total volatile base (TVB)

According to **Zhang *et al.* (2023)**, the level of freshness of fish can be divided into 4 criteria based on the TVB value, namely very fresh fish (10mg N/100 g), fresh fish (10-20mg N/100 g), fish suitable for consumption (20-30mg N/100 g), and fish not suitable for consumption if the TVB value is more than 30mg N/100 g. Table (4) shows that the

TVB value increases as the storage time increases. The TVB value at 0.8 and 16 hours of storage shows that tilapia is still suitable for consumption, while at 24 hours of storage, it shows that the TVB value has exceeded the standard of fresh fish suitable for consumption based on **SNI 2354.8: 2990**.

According to **Fahrul (2019)**, the condition and amount of TVB levels depend on the quality of the freshness of the fish; the more backward the quality of the fish, the more TVB levels will increase in number. The increase in TVB-N levels is due to the increase in the number of bacteria in connection with the continuing process of quality deterioration by microorganisms that produce young volatile bases such as ammonia **(Faisal *et al.*, 2020)**. If the freshness of the fish decreases, the volatile nitrogen content will increase, which will increase TVB-N levels **(Leiwakabessy *et al.*, 2024)**.

5. Peroxide number

The higher the peroxide number, the higher the degree of fat deterioration **(Jurid *et al.*, 2020)**. The results of this test showed that the average peroxide values did not increase drastically within 24 hours, and none exceeded the maximum peroxide limit for fish fit for consumption. The peroxide number of fresh fish is usually between 20 and 30 mEq oxygen/kg sample. If it exceeds the maximum limit, it will cause rancidity **(Vilkova *et al.*, 2022)**.

A high peroxide number indicates that the fat or oil has oxidized, but a lower number does not necessarily indicate an early oxidation condition **(Fahrul, 2019)**. Fat oxidation by oxygen occurs spontaneously if the fatty material is allowed to come into contact with air, while the speed of the oxidation process depends on the type of fat and storage conditions. The speed of fat oxidation increases with increasing temperature and decreases at low temperatures

CONCLUSION

Overall, the quality of tilapia marketed in Makassar City can be effectively maintained with consistent control of critical factors, such as storage temperature and handling.

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