

THE EFFECT OF FISH WEIGHT ON FREEZING TIME

Pengaruh Berat Ikan Terhadap Waktu Pembekuan

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ABSTRACT

Fish is a highly perishable fishery product because it contains approximately 70-80% water. Fresh fish was deterioration process quickly, so proper handling techniques are required, namely block freezing. Freezing is a decrease in the initial temperature to the freezing point. This study aims to determine the freezing time at different fish weights. The research method used is an experiment using 7 fish samples, namely banana fish, areca fish, wulan fish, pomfret fish, botan fish, tilapia, and catfish. The weight of each fish in this study was banana fish (22 g), areca fish (87 g), wulan fish (150 g), pomfret fish (85 g), botan fish (244 g), tilapia fish (247 g), and catfish (205 g). The freezing temperature experienced a rapid decrease in the 1st hour and began to slow down in the 2nd-3rd hour, remained at the 4th and 5th hours, then decreased again at the 6th hour and remained at the 7th and 8th hours, then the temperature decreased again at the 9th and 10th hours but remained at the 11th hour. At the 11th hour, the water surface in banana fish had frozen completely, pomfret, pinang, wulan, tilapia, catfish had not frozen completely, there were still small gaps, while botan fish had not frozen completely and there were still many gaps. The weight and species of the fish affect the freezing process.

Keywords: Fish, Freezing, Temperature, Time, Weight

ABSTRAK

Ikan merupakan produk perikanan yang *high perishable* karena sekitar 70-80% mengandung air. Ikan segar cepat mengalami proses kemunduran mutu sehingga diperlukan teknik penanganan yang tepat yaitu pembekuan blok. Pembekuan merupakan penurunan suhu awal sampai ke titik beku. Penelitian ini bertujuan mengetahui waktu pembekuan pada berat ikan yang berbeda. Metode penelitian yang digunakan adalah experiment dengan menggunakan 7 sampel ikan yaitu ikan pisang, ikan pinang, ikan wulan, ikan bawal, ikan botan, ikan nila, dan ikan lele. Berat masing-masing ikan pada penelitian ini yaitu pisang (22 g), ikan pinang (87 g), ikan wulan (150 g), ikan bawal (85 g), ikan botan (244 g), ikan nila (247 g), dan ikan lele (205 g). Suhu pembekuan mengalami penurunan yang cepat pada jam ke-1 dan mulai melambat pada jam ke-2-3, tetap pada jam ke-4 dan 5, kemudian menurun kembali pada jam ke-6 dan tetap pada jam ke-7 dan 8, kemudian suhu turun kembali pada jam ke-9 dan 10 namun tetap pada jam ke-11. Pada jam ke-11, permukaan air pada ikan pisang telah beku sempurna, ikan bawal, pinang, wulan, nila, lele belum beku sempurna masih ada celah sedikit, sedangkan ikan botan belum beku sempurna dan masih banyak celah. Berat dan spesies ikan mempengaruhi

proses pembekuan.

Kata Kunci: Berat, Ikan, Pembekuan, Suhu, Waktu

INTRODUCTION

Fish is a source of animal food with good nutritional content for health. Fish contains 20-30% protein, amino acids, fats, and is rich in omega-3 fatty acids, minerals, and vitamins (Hasanah *et al.*, 2025). High fish consumption can support human health. The protein in fish is easily digested and supports growth by forming new tissue and replacing damaged tissue. Fish consumption by pregnant women is good for fetal brain development. Fish consumption can prevent degenerative diseases (Rahma *et al.*, 2024).

Fish is a highly perishable fishery product because it contains approximately 70-80% water. Fresh fish quickly degrades, requiring proper handling techniques (Li *et al.*, 2022). Fish spoils quickly at room temperature due to its high protein content. Fish generally spoils more quickly than other food products. Fish spoilage is primarily caused by chemical and biochemical quality loss and subsequent damage caused by bacterial activity. Fish spoilage is a complex process involving physical, chemical, and microbial mechanisms.

One fish handling technique to maintain freshness is freezing (Nurilmala *et al.*, 2021). Freezing is a common method used in the fisheries industry to maintain the freshness of fish products. The freezing process affects the quality and weight of the fish produced. Freezing can significantly extend the shelf life of aquatic products, but with prolonged storage, fish quality gradually declines. Water content and its distribution within the meat tissue can change during the freezing process. The freezing method causes solid nucleation and ice crystal growth (Baltasar *et al.*, 2021).

Freezing is the process of transferring heat from a product at a higher temperature to one at a temperature below 0°C. Freezing aims to prolong the freshness of fish and maintain its quality by inhibiting bacterial activity (Basri *et al.*, 2021). Freezing is a process that lowers the temperature to below freezing. This temperature allows most of the water to turn to ice. The freezing point depends on the substances dissolved in the tissue fluid. The freezing process involves the removal of latent heat during the phase transition of water from liquid to solid and the removal of sensible heat, which depends on the temperature drop (Amin *et al.*, 2023). During the freezing process, cold air is passed through the product to be frozen (Yanuari *et al.*, 2024).

In the fish freezing process, freezing time is a critical factor to consider. Freezing time is defined as the time required to reduce the product temperature from its initial value to the target value at its thermal center, or the time elapsed between the start of freezing and the complete freezing of the product (Bulut *et al.*, 2018). Freezing time is influenced by freezing temperature, air velocity, and fish size. Larger fish generally experience longer freezing times due to their greater mass and volume, which affect the rate of heat transfer (Huo & Yang, 2023). Information on the freezing time of blocks in freezers with different fish weights is lacking, so a study is needed. This study aims to determine the freezing time of fish with different weights.

METHODS

The research method is an experiment using 7 treatments. The research was conducted at the Laboratory of the Faculty of Animal Husbandry, University of Jambi. The research samples used came from fish sold at the Talang Banjar traditional market, Jambi City. The samples consisted of betel nut fish, banana fish, wulan fish, pomfret, botan fish, tilapia, and catfish. Each fish was washed with running water and then drained. Then each fish was weighed and its weight recorded. A fish container was prepared and filled with 500 mL of water, then each fish was placed into the container. A thermometer was inserted into the

container and left for 5 minutes. The thermometer reading was recorded as time 0. The container was then closed and labeled according to the name of the fish. The container containing the fish was placed in the refrigerator freezer and the temperature changes were observed every hour until it was completely frozen with a thermometer. The thermometer readings were recorded every hour. The visual appearance was observed and every hour and the changes that occurred were recorded.

RESULTS

Fish is a highly perishable fishery product and therefore easily spoils. Fish freshness can be maintained longer using the block freezing method. The fish used in this study included banana fish, pinang fish, wulan fish, pompano, botan fish, tilapia, and catfish. The types of fish used in this study can be seen in Figure 1.

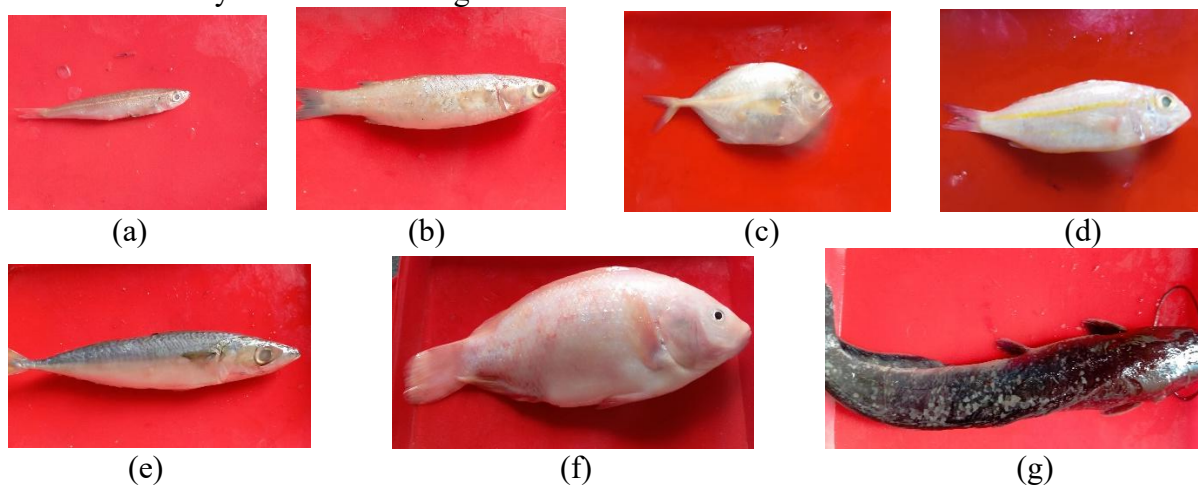


Figure 1. a) banana fish; b) pinang fish; c) pompano; d) wulan fish; e) botan fish; f) tilapia; g) catfish

These fish were then weighed using an analytical balance to determine their weight before they underwent the freezing process. The weights of various fish species are shown in Table 1.

Table 1. Weight of Various Fish Species in Block Freezing

No.	Types of Fish	Fish weight (g)
1.	Banana fish	22
2.	Wulan fish	150
3.	Pomfret fish	85
4.	Botan fish	244
5.	Tilapia fish	247
6.	Catfish	205
7.	Pinang fish	87

The fish were then placed in a container containing 500 mL of water and frozen in a freezer. The temperature drops from the start of freezing to freezing can be seen in Figure 2.

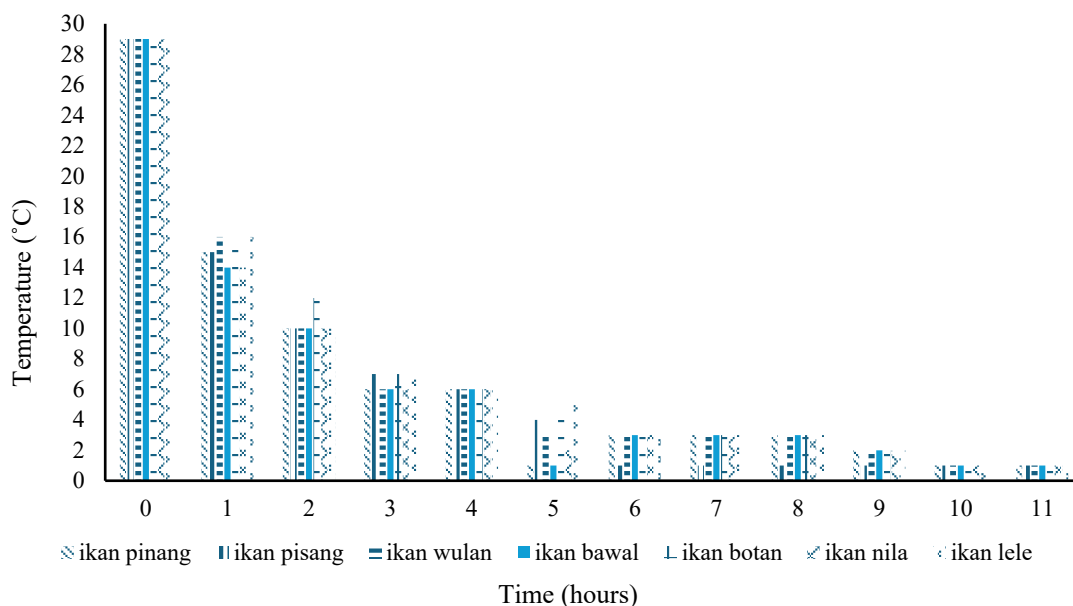


Figure 2. Temperature Drops in Various Types of Fish

DISCUSSION

The fish used were weighed. The weight of the fish used in this study can be seen in Table 1. The banana fish had the smallest weight, followed by pomfret, pinang fish, wulan fish, catfish, botan fish, and tilapia. Fish weight is influenced by the type and size of the fish. Smaller fish have a lower weight than larger fish. The type of fish also affects weight. Tilapia sold in markets are generally large, thus weighing more, while banana fish are generally smaller. Rizal & Jaliadi (2018) state that banana fish are 11-17 cm long and weigh 20-60 g. Wibowo et al. (2021) state that the preferred weight of tilapia is 250-500 g.

The weighed fish are then placed in containers, filled with water, and frozen in a freezer to undergo the freezing process. Freezing is the process of lowering the temperature of a product to its freezing point. In this study, the temperature reduction process during block freezing of various fish species and weights can be seen in Figure 1. At hour 0, the temperature of various fish species was 29°C, with no temperature difference across all species. This is because the fish were at room temperature, so no temperature change occurred.

At hour 1 after the fish were placed in the freezer, the temperature decreased by 45% compared to the initial temperature. The temperature reduction from hour 0 to hour 1 was very rapid. The temperature of various fish species frozen in blocks was 16°C for wulan, botan, and catfish, 15°C for pinang and pisang, and 14°C for pompano and tilapia. The temperature differences among the fish were due to the different species and weights. This pattern of temperature reduction during block freezing of fish is similar to research by Yanat & Baysal (2018), which found that in the initial freezing phase, the temperature decreases rapidly in the first 30 minutes. Cuesta et al. (2021) stated that the freezing process consists of three phases. The first phase is cooling from the initial temperature to the initial freezing point (the temperature at which freezing begins). This temperature is slightly lower than the freezing point of pure water due to the presence of dissolved components in it. The second phase consists of freezing from the freezing point to -5°C. The third phase is cooling from -5°C to the final temperature. Bao et al. (2023) stated that when the freezing process begins, the temperature decreases gradually and then the temperature reaches a plateau. Faster freezing results in a relatively lower temperature at the plateau, which is also observed in food freezing. Slow freezing, the formation of ice will release the latent heat of water and thus obtain heat dissipation through cooling. As a result, the system maintains a relatively constant temperature.

When the cooling rate is higher, the heat dissipation will be greater than the latent heat released; therefore, the equilibrium temperature will be lower.

The freezing temperature of the block at the second hour was 10°C for betel nut, banana fish, wulan fish, pomfret, tilapia, and catfish, while 12°C for botan fish. Botan fish have a slower temperature drop compared to other fish. This is because botan fish are larger than other fish except tilapia. Tilapia, although weighing approximately the same, have a faster temperature drop than tilapia because botan fish have a higher fat content compared to tilapia. Tilapia is a low-fat fish. This is because botan fish originates from the sea, which has a higher fat content than tilapia from freshwater. Pandiangan *et al.* (2023) stated that marine fish are rich in fat, especially EPA and DHA. Arsita *et al.* (2021) stated that the fat content of tilapia is 1.54%. The fat content of tilapia is classified as low.

The freezing temperature of the block at the 3rd hour was 7°C for banana fish, botan fish, catfish, and 6°C for pinang fish, wulan fish, pompano, and tilapia. During the 3rd hour of freezing, the temperature decrease was slower than during the 1st and 2nd hours. According to Yanat & Baysal (2018), the temperature decrease after 3 hours of freezing is not particularly rapid, but the pattern begins to slow. Mohammadipour & Duan (2024) stated that the liquid-to-solid phase change occurs during the recalescence stage. Recalescence has a nearly uniform temperature.

The freezing temperature of the block at the 4th hour was 6°C for all fish species. During this process, heat transfer from the fish's body no longer occurs. However, the energy gained is used to convert the water to a solid. Parandi *et al.* (2022) stated that the initial stage, where small ice crystals form, is influenced by factors such as temperature and the presence of impurities or nucleating agents. After nucleation, these crystals grow larger, and their size distribution can affect the texture and quality of frozen products. Cong *et al.* (2021) state that the freezing process involves several critical phase changes that significantly affect the properties of water and biological materials. During freezing, water transitions from a liquid to a solid state, undergoing nucleation and crystal growth, which are crucial for determining the characteristics of the final product. The freezing process can be divided into three main stages: initiation and propagation, freezing, and steady-state. Each stage exhibits distinct thermodynamic and morphological changes.

At 5 hours, the temperature drops to near freezing point. At this stage, the nucleation phase (freezing initiation) begins. Visually, ice flakes are already visible, although still small. As the temperature approaches freezing point, ice crystal nuclei begin to form. This is the initial stage of the transition from liquid to solid. Irsyad *et al.* (2020) state that the ice formation process is in the nucleation phase. At this stage, energy is no longer used for temperature reduction but for phase change.

At 6 hours, the temperature was 3°C for betel nut, wulan fish, pompano, botan fish, tilapia, and catfish, and 1°C for banana fish. The temperature difference between banana fish and the others was due to the smaller size of the banana fish. Ice crystal formation also occurred more rapidly in banana fish. Ice flakes began to form in greater numbers in banana fish compared to other fish. However, the botan fish formed fewer ice flakes.

At 7 and 8 hours, the temperature remained the same as at 6 hours, as heat transfer from the product to the environment was no longer occurring. However, energy was used for the transition from water to solid. Visually, the number of ice flakes increased compared to before. However, this time was longer than the study by Alief *et al.* (2024), which stated that freezing fish weighing 0.5-1 kg took 2 hours. This was because in this study, the freezing process used was block freezing, where the fish were added with 500 mL of water, whereas in Alief *et al.* (2024) study, only the fish were frozen.

At the 9th hour, the temperature of the banana fish remained constant, but the other fish experienced a temperature decrease of 2°C. The temperature decrease was very slow because

it had begun to enter the freezing stage, so more energy was used to change the liquid phase to solid compared to the temperature decrease. Visually, the banana fish had frozen completely on the surface, while for pomfret, wulan, and pinang fish, there was still a little water on the surface that had not frozen. In tilapia, botan, and catfish, the surface was still half liquid and froze more slowly than the others. At the 10th hour, the temperature of the banana fish remained constant, but the other fish experienced a temperature decrease of 1°C. At the 11th hour, the overall temperature of the fish was 1°C, and the water on the surface of the fish was completely frozen, but the water in the center of the fish was still not completely frozen. Liu *et al.* (2023) stated that there are three phases in the freezing curve: pre-cooling, phase change, and tempering (16–0°C, 0 to -5°C, and -5 to -18°C, respectively). Typically, the phase transition stage represents the critical region where most ice crystals form, which can directly affect the number and size of ice crystals.

CONCLUSION

During the freezing process, three phases of change occurred with fish of different weights. When the fish entered the freezer, the freezing temperature decreased rapidly in the first and second hours. Subsequently, the decrease in the fish's temperature began to slow and stagnate, but a phase change from water to solid began, marked by the formation of ice crystals in the sixth hour. Over the following hours, the ice crystals increased in number. By the eleventh hour, the surface of the water and fish were frozen, although some areas were still thawing in the center. The banana fish froze the fastest, and the botan fish took the longest to freeze. The weight and type of fish affected the freezing process.

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