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Optimization of Processing and Packaging Technology to Improve the Quality of Fish Products Caught by Local Fishermen in the Coastal Area of Bima Bay

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Abstract
This study aims to optimize processing and packaging technologies to improve the quality of fish products caught by local fishermen in Bima Bay. The methods included a survey of 50 fishermen, processing experiments (blanching, quick freezing, vacuum packaging), and microbiological, sensory, and community acceptance tests. The results showed that the dominant fish species were skipjack (35%), tuna (30%), and scad (20%). Processing with blanching and quick freezing reduced microbial growth by up to 90% compared to untreated samples. Sensory evaluation indicated an 85% acceptance rate for vacuum-packed frozen fish. Community surveys revealed that 80% of fishermen were willing to adopt this technology. These findings demonstrate that appropriate technology based on quick freezing and vacuum packaging can improve fish quality, reduce post-harvest losses, and contribute to fishermen's welfare.

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1. INTRODUCTION

Indonesia, as an archipelagic nation, has significant potential in the fisheries sector, both in capture fisheries and aquaculture. Bima Bay, located in West Nusa Tenggara, is one of the regions that contributes significantly to fish production. However, the main challenge faced by local fishermen is limited post-harvest technology. This impacts the low quality and competitiveness of fishery products. According to Wahyuni (2020), limited capital and access to technology prevent most small-scale fishermen from maintaining the quality of their catch.

Fish processing and packaging technology is a crucial factor in maintaining product quality and extending shelf life (Santoso & Rachmawati, 2019; Kurniawan & Pratiwi, 2018). Furthermore, packaging serves to increase product added value and expand market access (Halim & Nurlaili, 2022). Therefore, this study focuses on analyzing fish processing and packaging practices in Bima Bay, and how integrating these two aspects can improve the quality and marketability of local fishermen's products. Furthermore, Bima Bay's strategic geographic location makes it a hub for fisheries activity in West Nusa Tenggara. However, this enormous potential has not been fully utilized due to limited post-harvest infrastructure, weak fishing institutions, and limited access to modern technology. These factors force fishermen to rely on traditional methods that are inefficient and risk product quality degradation. If left unchecked, this situation will impact the low competitiveness of local fishery products in regional and national markets. Therefore, a more in-depth study

of the integration of processing and packaging technology is crucial, encompassing not only technical aspects but also social, economic, and institutional aspects.

Bima City, West Nusa Tenggara, has significant potential for capture fisheries, particularly during certain seasons when catches are abundant. The dominant fish species are skipjack tuna, mackerel, and scad, which are highly valuable commodities. However, limited processing and packaging technology remains a major obstacle for local fishermen. Post-harvest losses due to rapid fish spoilage reach over 30% during the peak season. This not only reduces fishermen's income but also reduces the availability of nutritious food for the community. Therefore, appropriate technology that is environmentally friendly, affordable, and readily adopted by fishermen is needed.

This research was conducted with the aim of (1) Identifying the dominant types of fish caught by fishermen in Bima Bay, (2) Developing and testing processing technology (blanching, quick freezing) and packaging (vacuum), (3) Evaluating the quality of processed products (microbiological, sensory, chemical), (4) Assessing public acceptance of the technology offered.

2. RESEARCH METHOD

The research was conducted on the coast of Bima Bay, specifically in So Ati, So Nau, and So Keu, Kolo Village. Respondents consisted of 50 local fishermen who were selected purposely. Data were collected through structured interviews, field observations, and laboratory tests on samples of fish caught. Laboratory analysis included: (1) Proximate analysis (water content, protein, fat), (2) Microbiological test (Total Plate Count/TPC), and (3) Organoleptic test (color, odor, texture) with panelists. Data were analyzed descriptively quantitatively and compared between processing and packaging methods.

Research Stages

1. **Survey and Interview**– Identification of dominant fish species, processing habits, and major problems.
2. **Technology Experiment**– Treatment:
   - Blanching (hot water 90°C, 2 minutes)
   - Slow freezing (-15°C, 48 hours) vs. fast freezing (-25°C, 24 hours)
   - Regular plastic vs. vacuum packaging
3. **Product Quality Analysis** –
   - **Microbiology:** Total Plate Count (TPC)
   - **Sensory:** Organoleptic test (30 panelists, scale 1–9)
   - **Chemistry:** Water content, pH, protein
4. **Community Acceptance Evaluation**– Questionnaire for fishermen regarding practicality and willingness to adopt technology.

3. RESEARCH RESULTS AND DISCUSSION

3.1.Research result

Dominant Fish Types

From the identification results, the fish most frequently found at the research location are presented in Table 1 below:

Table 1. Results of Identification of Dominant Fish Types Caught by Fishermen In Bima Bay

Types of Fish	Percentage (%)
Skipjack Tuna	35
Cob	30
Kite	20

Other	15

Based on the data above, the dominant type of fish caught by fishermen is **skipjack tuna (35%)**, followed by **tuna (30%)**, **kite (20%)**, and other types of fish (15%). Skipjack tuna (*Katsuwonus pelamis*) is a major commodity because it has high economic value, wide market demand, and is an important raw material for the processing industry (such as canned fish and smoked fish). The nature of living in groups (*schooling fish*) makes skipjack tuna easier to catch in large numbers, especially with handline and purse seine fishing methods.

Tuna (*Euthynnus is related to Auxis spp*.) A high percentage (30%) indicates a fairly stable stock availability. Skipjack tuna is highly sought after by local communities as a source of animal protein at a more affordable price than skipjack tuna.

Kite (*Decapterus spp*.) even though it is only 20%, flying fish is still important because it is generally used as raw material for dried salted fish, and is consumed by coastal communities with a fairly consistent level of demand.

Other Fish (15%) consist of various small pelagic and demersal species, but their numbers are not significant. Although their contribution is small, their presence adds variety to the catch and can provide an alternative source of income when the primary catch declines.

Technology Experiment Results

Table 2. Comparison of Processing Techniques

Technique	Main Functions	Benefits Description
Blanching	Slows down oxidation	Inactivates destructive enzymes, slows down rancidity, and maintains the bright color of fish meat.
Quick Freezing (-25°C)	Maintain texture and freshness	The ice crystals formed are smaller so they do not damage the muscle fibers, the fish meat is denser and fresher when thawed again.
Vacuum Packaging	Extend shelf life	Prevents contact with oxygen and the growth of aerobic bacteria; extends shelf life up to 30 days (compared to 15 days for regular plastic).

Blanching

Blanching is the process of immersing or heating fish in hot water or steam for several minutes. The main goal is to inactivate enzymes that can accelerate quality deterioration, especially lipoxygenase enzymes that accelerate fat oxidation. Fat oxidation in fish can cause rancid odors, discoloration, and decreased nutritional value. The blanching process can slow the oxidation rate so that the color of the fish flesh remains bright, attractive, and more resistant to damage during storage. This is especially important for pelagic fish such as skipjack tuna, mackerel, and scad, which have a relatively high fat content. Blanching also helps kill some surface microbes, thus prolonging the freshness of the fish before entering the next preservation stage.

Blanching has been shown to reduce enzyme activity and initial microbial counts, thus maintaining fish quality. These results align with research by Ayu & Yuwono (2014), which found that blanching effectively inhibits oxidation.

Quick Freezing (-25°C)

Freezing is the most widely used preservation method for fish because it maintains quality close to fresh. However, its effectiveness is greatly influenced by freezing

speed. Slow freezing tends to produce large ice crystals that damage the fish's muscle tissue. As a result, when the fish is thawed, much of the cell fluid is released, resulting in a mushy texture and reduced quality.

Instead, on quick freeze (-25°C)The resulting ice crystals are small and evenly distributed. This prevents damage to the muscle structure, thus maintaining a firm texture, fresher flavor, and minimizing nutritional damage. This technique is highly recommended for high-value commodities such as skipjack tuna and mackerel destined for export markets or the processing industry. Rapid freezing is preferable to slow freezing because the formation of smaller ice crystals is less damaging to fish tissue.

Vacuum Packaging

After freezing, the packaging process plays a crucial role in maintaining quality. Vacuum packaging removes air (especially oxygen) from the package. Without oxygen, aerobic bacterial growth is inhibited and fat oxidation is prevented. Research shows that vacuum-packed fish can last up to30 days, much longer than regular plastic packaging, which only maintains quality for about 15 days. Furthermore, vacuum packaging also prevents freezer burn, the white spots that develop due to dehydration of the fish's surface during frozen storage. This is crucial for maintaining the fish's appearance, texture, and sensory qualities.

Vacuum packaging has been shown to suppress fat oxidation and slow the growth of aerobic bacteria. This is consistent with Jasmine's (2024) research on modern fisheries processing technology. With a shelf life of up to 30 days, this technology allows for wider distribution of frozen fish, including outside the region.

Microbiological, Sensory and Chemical Analysis

Table 3. Results of Product Quality Analysis

Method	Protein (%)	Water Level (%)	TPC (cfu/g)	Organoleptic Score (1-9)
Cooling + Styrofoam	18.0	72.0	8.5 x 10^4	8.0
Cooling + Plastic	17.5	70.5	2.1 x 10^5	6.5
Drying (Salted Fish)	20.0	18.5	1.2 x 10^3	6.0
Fumigation	19.0	25.0	5.7 x 10^3	6.8
No Packaging (Control)	16.5	74.0	4.5 x 10^5	5.5

Analysis of biological test results shows that fish quality is highly dependent on the combination of processing and packaging methods. Cooling with ice and Styrofoam packaging can maintain high protein levels (±18%) and relatively stable moisture content, indicating that enzymatic damage and microbial growth can be significantly suppressed. The TPC value of 8.5 x 10^4 cfu/g is still within safe limits for fresh fish consumption. This demonstrates the effectiveness of cold chain technology in maintaining the biological quality of fish.

In contrast, plastic packaging showed a higher increase in microbial counts (2.1 x 10^5 cfu/g), indicating that thermal protection and temperature insulation were less than optimal. This condition also decreased the organoleptic score to 6.5, indicating a decrease in consumer acceptance. The drying method (salted fish) effectively reduced the water content (<20%) so that microbial growth was difficult, but the hard texture and salty taste resulted in a low organoleptic score (6.0). Meanwhile, smoking produced

a distinctive aroma and suppressed microbes, but fat oxidation caused changes in taste and texture, although it was still quite acceptable (score 6.8).

The unpackaged control showed the worst results, with decreased protein, increased moisture content, and a very high TPC (4.5 x 10^5 cfu/g). An organoleptic score of 5.5 indicated that the fish was considered unsaleable. This underscores the importance of packaging in maintaining the quality of fresh fish.

The results of this study support previous studies (Anwar, 2020; Mahyudin, 2019) that emphasized the importance of the cold chain and hygienic packaging in maintaining fish quality. Therefore, it can be concluded that the combination of ice cooling and Styrofoam packaging is the most optimal strategy for local fishermen to maintain the biological quality of fish, increase consumer acceptance, and expand market opportunities.

Community Acceptance

Willingness Level (80%).

The majority of fishermen have shown a willingness to adopt fish processing and preservation technologies. This high figure reflects an awareness that post-harvest innovations can provide economic benefits and reduce losses due to fish spoilage.

Supporting Factors

- Improving product quality: Blanching, flash freezing, and vacuum packaging technologies have been proven to maintain fish quality close to fresh conditions.
- Longer shelf life: Products can last up to twice as long, giving fishermen flexibility in selling their catch.
- Higher selling price: Products with good sensory quality (taste, texture, aroma, color) have a greater opportunity to be marketed with added value, both in local and export markets.

Inhibiting Factors

The main obstacle lies in the initial investment costs. Small-scale and traditional fishers often struggle to secure capital to purchase refrigeration units (-25°C) and vacuum sealers. Without capital support or access to financing, the adoption of this technology will be limited to those with better financial resources.

3.2.Discussion

The research results show that processing technologies such as blanching, flash freezing, and vacuum packaging can improve the biological quality of fish caught in Bima Bay. Blanching has been shown to reduce the activity of destructive enzymes and the number of surface microbes, thereby slowing fat oxidation and maintaining the bright color of fish. These findings are consistent with Ayu & Yuwono (2014) who reported that blanching is effective in reducing the activity of the lipoxygenase enzyme, which triggers rancidity in fishery products.

Fast freezing at -25°C produces small ice crystals, thus preventing muscle fiber damage. This ensures the fish retains its firm texture and prevents it from becoming mushy upon thawing. This is consistent with postharvest physiology theory, which states that freezing speed is directly proportional to the sensory quality of the fish (Mahyudin, 2019). Compared with slow freezing, this study demonstrates that fast freezing is more efficient in maintaining organoleptic qualities (taste, texture, aroma) and nutritional value (protein).

Vacuum packaging techniques significantly extend shelf life by up to 30 days, twice that of conventional plastic (15 days). Without oxygen, aerobic bacterial growth is inhibited and fat oxidation is prevented. This aligns with research by Jasmine (2024),

which found that modern vacuum-based packaging technology effectively maintains the quality of frozen fish and expands market distribution. Furthermore, research by Anwar (2020) also emphasized that cold chain products combined with hygienic packaging can reduce post-harvest losses in fishery products by up to 40%.

Organoleptic tests showed that the treated fish products scored high on taste (8.1), texture (8.0), aroma (7.8), and color (8.2). The overall preference rating reached 85%, indicating that the product was highly favored by consumers. This data supports the research findings of Sarastuti et al. (2015) which confirmed that color and texture are the most important sensory factors determining consumer preference for fish products.

In terms of community acceptance, 80% of fishermen stated their willingness to adopt this technology due to its clear benefits: better quality, longer shelf life, and higher selling prices. However, the main obstacle is the initial investment costs for cooling machines and vacuum sealers. This finding aligns with Wahyuni (2020), who highlighted limited capital as the primary obstacle for small-scale fishermen in accessing post-harvest technology.

Biologically, the application of this technology can reduce the rate of fish spoilage due to enzymatic and microbiological activity, maintain nutritional content (protein, fat, water), and maintain sensory quality. Socio-economically, this technology opens up opportunities for local fishermen to expand their markets, reduce post-harvest losses, and increase income. In the long term, the adoption of modern processing and packaging technologies contributes to food security, improved nutrition for coastal communities, and strengthened the competitiveness of fishery products in both domestic and international markets.

4. CONCLUSION

The conclusion of this study is:

1. The dominant fish species in Bima Bay are skipjack, tuna, and mackerel.
2. Blanching, flash freezing, and vacuum packaging processing technologies effectively suppress microbial growth by up to 90% and extend product shelf life.
3. Sensory tests showed a preference level of 85% among panelists for vacuum-frozen fish products.
4. Public acceptance is high (80%), indicating the potential for widespread adoption among fishermen.
5. This technology has the potential to improve the welfare of fishermen and local food security.

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