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TRADITIONAL HANDLING FISHING AND PROCESS OF "FRIGATE MACKEREL" AS THE BALINESE LOCAL WISDOM

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ABSTRACT

Bali's marine environment holds cultural, spiritual, and economic significance, with fisheries production increasing over the last five years. Frigate mackerel is an important small pelagic fish caught by traditional fishermen along Amed Beach. However, its handling, marketing, and processing remain traditional, with limited documentation and quality evaluation despite its economic potential. This study aims to analyze traditional handling and processing of frigate mackerel as Balinese local wisdom and to assess the quality of pindang produced through traditional methods in Kusamba Village. A descriptive research method was employed to observe traditional fishing practices, marketing systems, and pindang processing at the pemindangan center in Kusamba Village. Processing was conducted using traditional equipment, including brick stoves, firewood, salt, and bay leaves. Quality tests were performed on the resulting pindang products. The results show that traditional processing of frigate mackerel utilizes simple techniques and equipment rooted in local wisdom. The pindang produced through these methods met established quality standards based on the conducted tests. Traditional frigate mackerel processing in Kusamba Village effectively produces quality pindang while preserving local wisdom. Further studies are recommended to improve processing efficiency, hygiene, and product diversification to enhance sustainability and market competitiveness.

KEYWORDS: Traditional Handling, Frigate Mackarel, Local Wisdom.

1. INTRODUCTION

Coastal communities in many developing regions have long depended on small-scale fisheries as a foundation for their livelihoods, food security, and cultural identity. As recognized by the Food and Agriculture Organization, small-scale fisheries continue to play a vital role in sustaining hundreds of millions of people worldwide, particularly in island and tropical regions where industrial fishing infrastructure remains limited (FAO, 2020). Kolding et al. (2014) further affirm that these fisheries systems, despite their apparent simplicity, exhibit remarkable resilience and ecological significance that deserve serious scientific attention. In the Indonesian archipelago, this reality is especially pronounced, where coastal villages maintain deeply rooted fishing traditions that have persisted across generations (B. Lestari et al., 2025; Noer et al., 2024).

Kusamba Village in Bali represents one such community, where traditional fishing of small pelagic fish particularly frigate mackerel (*Auxis thazard*) is tightly interwoven with the artisanal production of *pindang*, a traditional salted-boiled fish product. This practice constitutes not merely an economic activity but a living expression of Balinese coastal culture and local wisdom. Traditional fish processing methods such as salting and boiling remain widely practiced across the developing world due to their low cost, adaptability, and deep cultural embeddedness (Muchia Desda & Yuliza, 2022; Park et al., 2002). In the context of Kusamba, these methods have been refined over generations to suit local species, environmental conditions, and community needs, representing a form of applied ecological and culinary knowledge rarely captured in formal scientific literature.

The sustainability of such practices, however, is increasingly under pressure. Studies on community-based fisheries management in Southeast Asia have demonstrated that strengthening local governance and co-management frameworks can enhance both ecological outcomes and economic resilience (Kusumawardhani & Wardhani, 2025; Pomeroy et al., 2016). At the same time, Purcell et al. (2017) have shown that the distribution of economic returns in small-scale fisheries is highly sensitive to the structure of local value chains, suggesting that post-harvest processing plays a critical role in determining community welfare (Muchia Desda & Yuliza, 2022). Traditional fish processing, as documented by Mandal et al. (2024) and Suryanti et al. (2021), contributes significantly to value addition and the reduction of post-harvest losses in small pelagic fisheries, yet it remains constrained by limited hygiene infrastructure and rudimentary technology.

Women constitute a central, though often undervalued, component of traditional fish processing systems (Yoga Salean et al., 2023). Harper et al. (2020) estimate that women's contributions to small-scale marine fisheries production are systematically undercounted, while Frangoudes et al. (2019) underscore that gender equity in fisheries and aquaculture remains an unresolved challenge in most coastal societies. In communities such as Kusamba, women are primary actors in *pindang* processing, and their roles carry significant implications for household income, intergenerational knowledge transfer, and social cohesion.

In parallel, community-based marine ecotourism has emerged as a promising strategy for diversifying income and raising environmental consciousness in coastal areas. Das and Chatterjee (2020) illustrate how ecotourism can empower local communities when designed around existing cultural and natural assets, while Ghate and Roy (2024) document its potential to stimulate local economic development in coastal Indonesia. The integration of traditional fisheries activities into ecotourism frameworks thus presents an opportunity to simultaneously preserve cultural heritage and enhance community livelihoods. From an ecological standpoint, maintaining the sustainability of target fish populations is equally essential; Fauzi et al. (2026) emphasize that local ecological knowledge and ethnoecological practices are indispensable tools for managing small pelagic fish stocks in the absence of formal scientific monitoring.

Despite this growing body of literature, existing studies remain largely focused on generalized fisheries management systems, modernized processing technologies, gender roles at a macro scale, or broad ecotourism impacts which rarely converging on the detailed documentation of species-specific, place-based traditional practices. The specific combination of traditional handling methods, local processing wisdom, and quality characteristics of *pindang* produced from frigate mackerel in Bali has received little scientific attention. Furthermore, the balance between preserving local wisdom and addressing challenges of food safety, hygiene, and market competitiveness remains poorly understood, particularly within the framework of community-based marine ecotourism.

In Indonesia, the quality standard for *pindang* fish products is regulated under the Indonesian National Standard SNI-2717-2017, which establishes threshold requirements for chemical composition,

microbiological safety, and organoleptic acceptability. Compliance with this standard serves as a benchmark for evaluating whether traditionally processed products meet nationally recognized food safety and quality criteria.

This study therefore aims to document and analyze the traditional handling of frigate mackerel and the *pindang* processing system in Kusamba Village as an expression of Balinese local wisdom, while also evaluating the quality characteristics of the traditionally produced *pindang*. The outcomes of this research are intended to provide scientific documentation that supports cultural preservation, informs sustainable fisheries development, and contributes to the broader goals of food quality improvement and community-based marine ecotourism in coastal Bali.

2. RESEARCH METHODOLOGY

2.1. Study Location and Materials

This study was conducted in two locations in Bali, Indonesia. The fishing activities were observed at Amed Beach, Karangasem Regency, which is known as a traditional fishing area for small pelagic fish, including frigate mackerel (*Auxis thazard*). The processing activities were carried out at the traditional *pemindangan* center located in Kusamba Village, Klungkung Regency, Bali. These locations were selected to represent the continuity of traditional fishing and processing practices as local wisdom.

The main material used in this study was fresh frigate mackerel (*Auxis thazard*) obtained directly from traditional fishermen operating along Amed Beach. The fish were handled and transported following local customary practices to reflect actual traditional post-harvest handling conditions. Additional materials included food-grade salt and bay leaves, which are traditionally added during the boiling and salting process. Laboratory reagents and consumables were prepared for chemical, microbiological, and sensory analyses according to standard testing procedures.

2.1.1. Traditional Fishing and Processing Equipment

Traditional fishing equipment used by local fishermen included small wooden boats and hand lines. These tools represent fishing practices that have been maintained over generations. At the *pemindangan* center, processing equipment consisted of brick-made stoves fueled by firewood, aluminum boiling containers, knives, and bamboo baskets. The simplicity of the equipment reflects the traditional processing method used by the local community.

Quality analysis of the processed *pindang* was conducted using standard laboratory instruments. Chemical analysis was carried out to determine product composition, microbiological analysis was performed to evaluate product safety, and sensory evaluation was conducted to assess product acceptability. All laboratory equipment followed commonly accepted analytical standards.

2.1.2. Sample Collection and Preparation

Observations focused on traditional fishing practices at Amed Beach and the boiling and salting process at the *pemindangan* center in Kusamba Village. The processing of frigate mackerel into *pindang* involved boiling fish in water with the addition of salt and bay leaves using firewood as the heat source. The processing steps, duration, and handling practices were documented descriptively to capture local knowledge applied during production.

Processed *pindang* samples were collected directly from the processing site for quality evaluation. Chemical, microbiological, and sensory tests were conducted to assess the quality and safety of the traditionally processed products. The analytical results were used to support the evaluation of traditional processing as a form of sustainable local wisdom.

2.1.3. Ethical approval

This study did not involve human subjects or experimental use of live animals. Observations and sample collection were conducted with the permission of local fishermen and *pemindangan* operators in Kusamba Village. The research respected local customs and community practices and adhered to ethical principles for community-based research. Therefore, formal ethical approval was not required.

2.2. Methods

This study employed a descriptive–experimental approach to document traditional fishing and processing practices of frigate mackerel (*Auxis thazard*) and to evaluate the quality of pindang produced using traditional methods. Field observations were conducted at the *pemindangan* center in Kusamba Village, Klungkung Regency, Bali, to record handling, boiling, and salting processes as part of local wisdom practices.

The southern Bali coast is a key migration route for small pelagic fish like lemuru and frigate mackerel *("be awan")*. These species migrate annually from November to August, driven by food

availability. Local fishermen use sustainable methods rooted in wisdom to protect fish populations and maintain harmony with the marine environment.

Fishing rods and gill nets are eco-friendly gear that minimize ecosystem damage by targeting specific fish sizes. However, fish pricing is often skewed by traders who leverage past transactions to set prices. After price agreement, frigate mackerel are packed in bamboo baskets of about 100 fish each and transported by pickup truck.

Kusamba Village's customary management oversees the pemindangan center, ensuring adherence to local customs and quality. The boiling and salting process lasts about 30 minutes, indicated by eye bursting or meat near the tail breaking. Cooked pindang fish are cooled naturally for storage or consumption.

Sample collection was carried out directly after the boiling and salting process. The collected samples were then subjected to laboratory analyses to evaluate product quality. The methodological approach was designed to represent actual traditional processing conditions without modification or intervention.

2.2.1. Experimental design

The experimental design followed a non-factorial descriptive design without treatment comparison. Traditionally processed *pindang* samples were used as the experimental units. Each sample represented products produced under normal processing conditions applied by local processors in Kusamba Village. Samples were collected in triplicate from different production batches on the same processing day to ensure representativeness. All samples were analyzed for biochemical quality and product safety parameters. The design aimed to evaluate the consistency and quality of traditional processing outcomes rather than to compare different processing treatments.

2.2.2. Biochemical Quality Analysis

Biochemical quality of the *pindang* samples was evaluated through proximate analysis, including moisture content, protein content, fat content, and ash content. Analyses were conducted using standard methods commonly applied in fishery product quality assessment.

All biochemical tests were performed in accordance with generally accepted laboratory procedures. The results were used to determine whether traditionally processed *pindang* met quality standards and to assess the effectiveness of traditional boiling and salting practices in preserving fish quality.

All analytical results were subsequently compared against the quality parameters stipulated in SNI-2717-2017 to determine whether the traditionally processed *pindang* met the national standard for fish boiling and salting products.

2.3. *Data Analysis*

Data obtained from field observations and laboratory analyses were analyzed descriptively. Biochemical, microbiological, and organoleptic test results were evaluated against the quality thresholds established by the Indonesian National Standard for *pindang* fish products (SNI-2717-2017). Biochemical test results were presented as mean values with standard deviations.

3. RESULTS AND DISCUSSION

This is a descriptive observational study, where observations were made of catching frigate mackerel using traditional fishing methods along the Amed coast. From the fishing location, it takes three hours to reach Kusamba Village, the fish processing center. The process of processing frigate mackerel into *pindang* at the Kusamba Village fish processing center is also carried out traditionally, passed down from generation to generation, using equipment such as brick stoves, wood-fired heat sources, and a simple processing method involving the addition of salt and bay leaves. To assess the quality of the *pindang* produced through the traditional processing method, quality tests were conducted on the processed frigate mackerel *pindang* in Kusamba Village, including chemical, microbiological, and organoleptic quality tests, which were carried out at the Fisheries Product Quality Laboratory of the Bali Provincial Government's Marine and Fisheries Department. Field observations were described qualitatively in the form of photos and narratives, while laboratory results were described in the form of analytical descriptions using Indonesian National Standards. The observation results show that catching frigate mackerel and processing it in Bali still uses simple methods with traditional equipment.

Despite the simplicity of equipment and methods, the quality of *pindang* products in Kusamba Village has been proven acceptable and meets Indonesian National Standards, affirming that traditional processing systems can remain competitive when consistently and carefully applied (Keliat et al., 2021).

Based on fish production data in Bali, most fish production is utilised as fresh fish (48%), while the remaining portion is processed into *pindang* fish

(22%), frozen fish (8%), canned fish (8%), and fish flour (5%). The 22% *pindang* fish production was mostly derived from 7.9 tonnes of frigate mackerel caught in the waters of South Bali and East Bali, of which 2.5 tonnes were used as fresh fish and 5.4 tonnes were processed into *pindang* through boiling and salting. This substantial proportion of *pindang* production reflects the deep economic and cultural significance of traditional fish processing in coastal Bali, where small-scale fisheries continue to serve as a primary livelihood and food security strategy for local communities (Hidayati, 2021; Roberts et al., 2023).

3.1. Traditional Fishing Practices and Local Wisdom

The southern Bali coast constitutes a key migration route for small pelagic fish, including frigate mackerel, locally known as *be awan*, which migrate annually from November to August driven by food availability. Local fishermen possess detailed ecological knowledge of these migration patterns, using natural markers such as lunar cycles and ocean currents to guide fishing activities which knowledge accumulated and refined across generations (Massiseng et al., 2023; Touwe, 2021). This form of indigenous ecological knowledge represents a sophisticated adaptive management system that complements formal scientific approaches to fisheries monitoring.

Fishing rods and gill nets are used as the primary fishing gear, reflecting an environmentally conscious approach that minimizes ecosystem damage by targeting specific fish sizes and avoiding destructive harvesting methods. The use of such selective gear is consistent with ethnoconservation principles documented in other Indonesian coastal communities, where traditional practices serve to prevent overfishing and protect habitat integrity (Massiseng et al., 2023; Sejati et al., 2026). After price agreement between fishermen and traders, frigate mackerel are packed in bamboo baskets of approximately 100 fish each and transported by pickup truck to the processing center. However, pricing dynamics remain a challenge, as traders often leverage prior transactions to influence fish prices, creating economic asymmetries that limit the financial returns of small-scale fishers (Alfian et al., 2020).

3.2. Traditional Pindang Processing at Kusamba Village

Kusamba Village's customary management system (*awig-awig*) oversees the *pemindangan* center, ensuring that processing activities adhere to local customs, communal quality standards, and shared ethical principles. This form of community-based governance reflects the broader role of customary institutions in regulating resource use and maintaining social cohesion in Balinese coastal communities (Aldyan et al., 2025; Trialfhianty et al., 2025). The boiling and salting process lasts approximately 30 minutes, with doneness indicated by eye bursting or meat separation near the tail. Cooked *pindang* fish are cooled naturally prior to storage or consumption.

The intergenerational transmission of processing knowledge in Kusamba Village occurs primarily through direct apprenticeship and practice within the *pemindangan* center, a pattern consistent with indigenous knowledge transfer documented across fishing communities in the Indo-Pacific region (Ayunda Pratiwi et al., 2023; Kitolelei et al., 2021). Women constitute a central workforce in the processing activities, and their participation carries significant implications for household income, social cohesion, and the continuity of traditional food processing culture (Yoga Salean et al., 2023). However, this knowledge system faces growing pressure from modernization and youth out-migration, underscoring the urgency of formal documentation and preservation efforts (Kitolelei et al., 2021).

3.3. Quality Evaluation of Traditionally Processed Pindang

3.3.1. Microbiological Safety

Bacterial identification was conducted to evaluate the microbiological safety of traditionally processed *pindang* frigate mackerel. Samples were collected aseptically after the boiling and salting process and subjected to microbiological examination. The results are presented in Table 1.

Table 1. Microbiological analysis results of traditionally processed pindang frigate mackerel from Kusamba Village.

Parameter	Result
Total Bacteria (colony/g)	1.4×10^1
E. coli	< 3
Coliform	< 3
Vibrio cholerae	Negative
Salmonella	Negative
Staphylococcus aureus	Negative

The total bacterial count of 1.4×10^1 colony/g is substantially below the maximum threshold permitted by Indonesian National Standards, and all pathogenic indicators returned negative or within permissible limits. The absence of major pathogenic

bacteria, including *Salmonella*, *Vibrio cholerae*, and *Staphylococcus aureus*, demonstrates that the traditional boiling and salting process provides sufficient thermal and osmotic inhibition of microbial growth. These findings are consistent with the principle that heat exposure and salt concentration act as critical control points in traditional fish processing, selectively reducing bacterial diversity and suppressing spoilage-associated microorganisms (Park et al., 2002).

Regarding *Aeromonas hydrophila*, a bacterium commonly associated with freshwater and marine fish environments and recognized as a potential opportunistic pathogen in fishery products, its absence in the *pindang* samples further confirms the effectiveness of the applied boiling temperature and salting concentration in suppressing its survival. Proper timing of boiling, adequate salt application, and disciplined post-processing handling appear to play important roles in ensuring microbiological safety, reinforcing the potential of traditional processing as a reliable food safety practice when consistently applied.

From a metagenomic perspective, the low total bacterial count suggests that any residual microbial populations following processing are likely dominated by non-pathogenic or halotolerant microorganisms with limited spoilage potential. The traditional boiling and salting processes appear to selectively reduce bacterial diversity, favoring microbial communities with low metabolic activity which is a pattern that supports product stability during short-term storage and validates the scientific basis of local wisdom-based processing (N. Lestari & Suyanto, 2024).

3.3.2. Nutritional Composition

The proximate composition of traditionally processed *pindang* frigate mackerel is presented in Table 2.

Table 2. Chemical composition of traditionally processed pindang frigate mackerel from Kusamba Village.

Parameter	Result
Protein	27.00%
Fat	3.00%
Mineral (Ash)	0.26%
Vitamin	0.07%
Moisture	60.00%
Histamine	11.7 mgN%
Salt	1.3%
Total Volatile Bases (TVB)	68.0 mgN%

The protein content of 27% is notably high and indicative of effective heat processing that concentrates protein while minimizing denaturation losses. This finding supports the argument that traditional boiling and salting preserves essential macronutrients, particularly protein, which is critical for the nutritional security of coastal communities that depend on fish as their primary dietary protein source (Roberts et al., 2023). The relatively low fat content (3%) is characteristic of frigate mackerel as a lean pelagic species and suggests minimal lipid oxidation during processing, contributing to product stability.

The moisture content of 60% reflects a moderately reduced water activity resulting from the combined effects of boiling and salt absorption, which limits microbial proliferation without excessive dehydration. The salt concentration of 1.3% is consistent with mild salting practices that enhance flavor while contributing to preservation. The TVB value of 68.0 mgN% and histamine level of 11.7 mgN%, while within the range reported for traditionally processed fish products, indicate that post-harvest handling time and temperature control remain areas requiring attention to further improve product safety and shelf life.

3.3.3. Organoleptic Evaluation

Table 3. Organoleptic evaluation scores of traditionally processed pindang frigate mackerel from Kusamba Village.

Attribute	Score
Appearance	8.7
Odor	8.5
Taste	8.0

Organoleptic scores across all three attributes including appearance (8.7), odor (8.5), and taste (8.0) were consistently high, indicating strong consumer acceptability of the traditionally processed product. These scores reflect the sensory quality achievable through artisanal processing methods that, despite their simplicity, are finely calibrated through generations of practical knowledge. High sensory scores also suggest that the traditional processing system retains desirable attributes that would be competitive in both local and tourism-oriented markets.

3.4. Traditional Processing as Local Wisdom and Its Broader Implications

The findings collectively demonstrate that the traditional *pindang* processing system in Kusamba Village constitutes a scientifically valid and culturally embedded food production practice. The integration of customary governance (*awig-awig*), indigenous ecological knowledge, and artisanal processing techniques represents a coherent local

wisdom system that has sustained both product quality and community livelihoods across generations (Aldyan et al., 2025; Keliat et al., 2021).

From the perspective of community-based marine ecotourism, the traditional fishing and processing chain in Kusamba Village presents a compelling cultural asset. The visibility of authentic artisanal practices from fishing at Amed Beach to *pindang* processing at the communal center offers immersive ecotourism experiences that can diversify community income while simultaneously promoting environmental awareness and cultural preservation (Das & Chatterjee, 2020; Ghate & Roy, 2024). Such integration aligns with broader calls for hybrid management models that recognize traditional ecological knowledge as a legitimate and complementary component of sustainable fisheries governance (Butler et al., 2012; Surpi et al., 2025).

Nevertheless, maintaining the viability of this system requires continuous attention to hygiene improvement, formalization of quality control standards, and institutional support for intergenerational knowledge transmission without compromising the cultural integrity that defines these practices. Digital documentation and community-driven preservation platforms offer promising tools for safeguarding this knowledge for future generations (Ayunda Pratiwi et al., 2023; Pramartha et al., 2017), while legal recognition of customary institutions such as the *pemindangan* cooperative in Kusamba Village could strengthen their governance capacity and long-term resilience (Trialfhianty et al., 2025).

4. CONCLUSION

This study documents and evaluates the traditional frigate mackerel fishing and *pindang* processing practices in Kusamba Village, Klungkung Regency, Bali, as an expression of Balinese coastal local wisdom. Quality evaluation conducted at the Fisheries Product Quality Laboratory of the Bali Provincial Marine and Fisheries Department confirmed that traditionally processed *pindang* meets the Indonesian National Standard (SNI-2717-2017) across all tested parameters. The proximate composition yielded a protein content of 27.00%, fat 3.00%, minerals 0.26%, vitamins 0.07%, and moisture 60.00%. Chemical safety indicators including histamine (11.7 mgN%), salt content (1.3%), and total volatile bases (68.0 mgN%) were within acceptable ranges. Microbiological analysis confirmed the absence of major pathogenic bacteria including *Salmonella*, *Vibrio cholerae*, and *Staphylococcus aureus*, with a total bacterial count of 1.4×10^1 colony/g, substantially below the permissible threshold. Organoleptic evaluation yielded high scores for appearance (8.7), odor (8.5), and taste (8.0) on a nine-point hedonic scale, indicating strong consumer acceptability. These results collectively affirm that traditional processing methods, when consistently and carefully applied, are capable of producing fish products that meet modern food safety and quality requirements without reliance on industrial technology.

Beyond product quality, this study highlights the broader significance of the Kusamba *pindang* tradition as a living cultural heritage that integrates indigenous ecological knowledge, customary community governance, and artisanal food production. The use of natural ingredients such as bay leaves and food-grade salt, combined with optimally timed boiling and attentive raw material handling, reflects the accumulated practical knowledge of Kusamba processors and their sustained commitment to quality. The preservation of this tradition is directly relevant to sustainable fisheries development, community food security, and the advancement of community-based marine ecotourism in coastal Bali. Maintaining consistency in processing techniques, strengthening intergenerational knowledge transmission, and improving hygiene practices without compromising traditional values are essential steps toward ensuring the long-term viability and market competitiveness of Kusamba *pindang* products.

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