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Freshness Evaluation of Minced Fish (Snakehead, Spotted Mackerel, Snapper, and Sardine) Sold at a Traditional Market in Palembang Using Chemical, Physical, Microbiological, and Sensory Parameters

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Abstract

ABSTRACT
Background: Minced fish is widely marketed in traditional markets due to its practical use as raw material for various processed fish products. However, mechanical mincing under inadequate hygiene and cold-chain management may lead to an increase in Total Plate Count (TPC), thereby accelerating quality deterioration and increasing potential food safety risks.
Objective: This study evaluated the freshness and quality of minced fish sold in a traditional market using integrated chemical, physical, microbiological, and sensory indicators.
Methods: A purposive sampling approach was applied to four types of minced fish sold at Perumnas Sako Kenten Market, Palembang: snakehead (*Channa striata*, S1), spotted mackerel (*Scomberomorus guttatus*, S2), snapper (*Lutjanus campechanus*, S3), and sardine (*Sardinella lemuru*, S4). Analyses included proximate composition, pH, Total Volatile Base Nitrogen (TVB-N), Trimethylamine Nitrogen (TMA-N), Total Plate Count (TPC), descriptive sensory scoring, and hedonic evaluation. Results were interpreted descriptively and compared with Indonesian National Standards (SNI) and relevant literature.
Results: All samples exhibited TPC values exceeding the SNI limit (1×10^6 CFU/g), ranging from 1.6×10^7 to 2.8×10^7 CFU/g. TVB-N values remained low (6.0–7.6 mgN/100 g), while elevated TMA-N levels were observed in spotted mackerel and sardine, indicating reduced freshness in pelagic species. Sensory evaluation showed good acceptance for snakehead, spotted mackerel, and snapper, whereas sardine received neutral to low scores, particularly for aroma and texture.
Conclusion: The quality of minced fish varied among species, while microbial contamination consistently exceeded safety limits. Sensory evaluation remains important but insufficient alone; therefore, integrated freshness assessment supported by improved hygiene and cold-chain management is essential.

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INTRODUCTION

Fish is widely recognized as an important food commodity with high nutritional value, serving as a major source of animal protein, healthy lipids, vitamins, and essential minerals (FAO, 2022). In Indonesia, the consumption of fishery products has continued to increase, driven by growing public awareness of balanced nutrition and the adoption of healthier dietary patterns.

Among various fish-based products, minced fish meat is particularly popular due to its versatility and ease of use. It is commonly utilized as the main ingredient in traditional foods such as *pempek*, *tekwan*, and other local culinary products, making it highly demanded by household-scale producers and small food enterprises.

Despite its popularity, fish is a highly perishable commodity. When processed into minced form, its susceptibility to quality deterioration becomes even greater, especially if handling, processing, and storage conditions do not comply with food safety standards (Bi, 2024). Mechanical comminution such as mincing significantly increases the exposed surface area of fish muscle, thereby accelerating enzymatic activity, lipid oxidation, and microbial proliferation compared to whole fish. Consequently, minced fish products are recognized as high-risk commodities that require stricter quality control and freshness evaluation using integrated analytical approaches that showed in several studies (Prabhakar et al., 2020; Dalgaard, 2014; Salama & Chennaoui, 2024). Therefore, maintaining the freshness and safety of minced fish products is a critical issue in the fishery supply chain, particularly in traditional market settings.

Quality degradation of minced fish occurs through complex biochemical and microbiological processes. Declining freshness is commonly associated with the formation of Total Volatile Base Nitrogen (TVB-N) and Trimethylamine Nitrogen (TMA-N), which result from protein and nitrogenous compound breakdown and contribute to unpleasant odors and flavors. These compounds are widely used as chemical indicators of fish spoilage. In addition, an increase in pH value often reflects microbial metabolic activity, while elevated Total Plate Count (TPC) levels indicate microbial proliferation that may pose health risks to consumers (Prabhakar et al., 2020; Tavares et al., 2021). TVB-N and TMA-N are widely applied as chemical indicators of fish freshness, while TPC is commonly used to assess microbiological quality and safety. However, previous studies have demonstrated that chemical indicators alone may not reliably reflect microbial risks, particularly in comminuted fish products such as minced fish (Kim et al., 2023; Zhang et al., 2022; Zhuang et al., 2021). Several studies have emphasized that minced fish products are particularly vulnerable to microbial contamination due to their increased surface area and frequent exposure during processing. Sensory evaluation remains an essential tool for assessing market acceptability and consumer perception of fish freshness, especially during the early stages of spoilage, when products may still appear organoleptically acceptable despite elevated microbial loads (Grassi et al., 2023; Prabhakar et al., 2020). Sensory attributes such as appearance, aroma, texture, and overall acceptability are commonly used to assess freshness; however, sensory evaluation alone may not always correlate with microbiological safety (Dali & Husain, 2020; Cardoso et al., 2010). Consequently, an integrated assessment combining chemical, physical, microbiological, and sensory analyses is necessary to obtain a comprehensive evaluation of minced fish quality.

Although numerous studies have investigated the freshness and safety of whole fish and certain processed fish products, comprehensive evaluations of minced fish sold in traditional markets remain limited. In particular, there is a lack of studies that simultaneously assess chemical parameters (proximate composition, TVB-N, and TMA-N), physical characteristics (pH), microbiological quality (TPC), and sensory attributes across multiple fish species. This limitation is especially evident in traditional markets such as Pasar Perumnas Sako Kenten, Palembang, which continues to serve as a primary source of fish and fish-based products for local communities.

Traditional markets play a vital role in food distribution in Indonesia; however, they often face challenges related to hygiene, sanitation, and temperature control. Without adequate monitoring, the decline in freshness of minced fish products may lead to economic losses, reduced consumer trust, and increased risks of foodborne illness. Conversely, proper evaluation and control of minced fish freshness can enhance product quality, ensure consumer safety, and add value to local fishery commodities. Therefore, a scientific assessment of minced fish freshness in traditional markets is essential to support quality control efforts and food safety management.

The purpose of this study was to evaluate the freshness and quality of minced fish from several fish species sold in a traditional market in Palembang using an integrated approach involving chemical, physical, microbiological, and sensory analyses. It was hypothesized that variations in fish species and market handling practices would result in differences in freshness indicators and microbiological quality. The findings of this study are expected to contribute to the field of fishery product technology and food safety, as well as support governmental and stakeholder initiatives

aimed at strengthening food safety as part of national priority programs, including the Asta Cita framework (Kim et al., 2023).

METHOD

Research Design

This study employed a descriptive quantitative research design to evaluate the freshness and quality of minced fish sold in a traditional market. The assessment was conducted through an integrated approach involving chemical, physical, microbiological, and sensory analyses. The study aimed to describe the quality condition of minced fish samples based on laboratory test results and to compare these findings with established quality standards issued by relevant authorities and previous studies.

Participants

Sensory evaluation was conducted by twelve semi-trained panelists who were familiar with fish and fishery products. The panelists assessed the sensory attributes of minced fish samples, including appearance, aroma, texture, and overall quality, based on predefined evaluation criteria provided in the sensory score sheets.

Population and Methods of Sampling

The study population consisted of minced fish products sold in Pasar Perumnas Sako Kenten, Palembang, Indonesia. Samples were collected using purposive sampling from vendors who prepared and minced the fish on the same day as sample collection. Four types of fish species were selected: snakehead fish (*Channa striata*), spotted mackerel (*Scomberomorus guttatus*), snapper (*Lutjanus campechanus*), and sardine (*Sardinella lemuru*). Approximately 1000 g of minced fish was collected for each species. Sampling was conducted once (one-time sampling) without replication.

Instrumentation (Sample of Questions, Scoring Method, and Psychometric Properties)

Sensory evaluation instruments consisted of scoring and hedonic test sheets adapted from the Indonesian National Standard for sensory evaluation of fishery products (BSN, 2006). The scoring method assessed appearance, aroma, and texture using a numerical scale ranging from 1 (very poor quality) to 9 (excellent quality). The hedonic test evaluated panelists' preference levels using a nine-point scale from "dislike extremely" to "like extremely." The instruments were reviewed prior to use to ensure clarity and consistency, while validity was ensured through reference to standardized sensory evaluation guidelines. Reliability was supported by the use of trained panelists and uniform evaluation conditions.

Instrument

The instruments used in this study included a cold box for sample transportation, an analytical balance (Ohaus, USA), drying oven (Memmert, Germany), Soxhlet extractor (Iwaki, Pyrex, Indonesia), Kjeldahl apparatus (Gernhard, Germany), digital pH meter (Eutech, Singapore), spectrophotometer (B-One, China), bacterial culture media (Plate Count Agar), incubator, and standard laboratory glassware for chemical and microbiological analyses. Sensory evaluation instruments included white bowls, spatulas, scoring sheets, and controlled evaluation tables and seating.

Procedures and Time Frame

The study was conducted from July to September 2025. Sample preparation was carried out at the Fishery Product Processing Technology Workshop, Faculty of Fisheries and Marine Science, University of PGRI Palembang. Chemical, physical, microbiological, and sensory analyses were performed at the Chemical and Microbiology Laboratory of Agricultural Products, Department of Agricultural Technology, Faculty of Agriculture, University of Sriwijaya.

Chemical Analyses included proximate composition (moisture, protein, fat, ash, and carbohydrate by difference) following SNI 01-2891-1992 (BSN, 1992). Total Volatile Base Nitrogen (TVB-N) and Trimethylamine Nitrogen (TMA-N) analyses were conducted according to SNI 2354.8:2009 (BSN, 2009a) using titration and spectrophotometric methods, respectively. **Physical** analysis involved pH measurement using a digital pH meter on homogenized samples. **Microbiological** quality was assessed through Total Plate Count (TPC) using the pour plate method on PCA agar, followed by incubation at 35–37°C for 24–48 hours in accordance with SNI 2332.3:2015 (BSN, 2009b). The selection of TVB-N, TMA-N, pH, and TPC as freshness indicators was based on their wide acceptance in international fish quality assessment and their relevance for evaluating comminuted fish products marketed under traditional handling conditions (Dalgaard, 2014; Kim et al., 2023). **Sensory** evaluation of minced fish samples was conducted by twelve panelists. The assessment focused on appearance, aroma, texture, and overall quality of the minced fish, based on predefined quality criteria provided in the evaluation sheets. The sensory analysis was performed using a modified version of the Indonesian National Standard method SNI 01-2346-2009 (BSN, 2006).

Analysis Plan

Data obtained from chemical, physical, microbiological, and sensory analyses were analyzed descriptively. Results were compared with quality standards established by the Indonesian National Standardization Agency (BSN) and relevant literature. Sensory data were presented as mean values and interpreted based on predefined sensory quality criteria. The results were displayed in tables and graphical formats to illustrate the freshness condition of each minced fish sample. Ordinary descriptive statistical methods were applied without further inferential testing.

Scope and Limitations of the Methodology

This study focused on evaluating the freshness of minced fish from selected species collected from a single traditional market, using one-time sampling without replication. Consequently, the findings may not fully represent temporal variations, seasonal influences, or differences among vendors. In addition, the absence of advanced statistical analysis limits the ability to generalize the results beyond the observed samples.

RESULTS AND DISCUSSION

Results

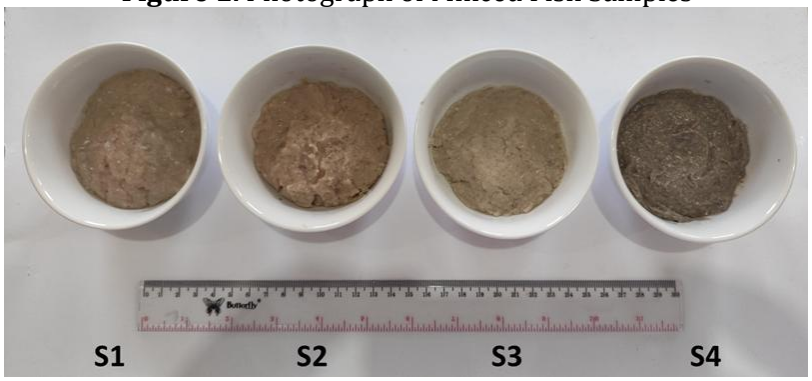
The freshness attributes of minced fish differed among the examined fish species, indicating the influence of biological characteristics as well as variations in handling and processing practices at the traditional market level. Differences observed in chemical, physical, microbiological, and sensory parameters provide a clear overview of the quality status of minced fish products available to consumers.

As shown in Table 1, the pH values of the minced fish samples ranged from slightly acidic to near neutral, which is generally indicative of the early post-mortem condition of fish muscle. TVB-N values remained within ranges 6.00 – 7.60 mg N/100 g commonly associated with acceptable freshness, suggesting that severe spoilage had not yet developed at the time of sampling. However, relatively higher TMA-N concentrations (2.74 – 14.54 mg N/100 g) were detected in certain samples, particularly those derived from marine fish species, indicating a decline in freshness.

Microbiological examination showed relatively high TPC values in all samples (1.6×10^7 - 2.8×10^7 CFU/g; Tabel 1). This result reflects suboptimal sanitation practices and insufficient temperature control during mincing, storage, and marketing processes.

Sensory evaluation results were generally consistent with the analytical findings. Samples with elevated microbial loads and higher chemical spoilage indicators tended to receive lower scores, especially for aroma and texture, although some samples were still considered organoleptically acceptable (Table 2 and Table 3).

Figure 1. Photograph of Minced Fish Samples



Note: Minced fish samples of S1: snakehead fish (*Channa striata*); S2: spotted mackerel (*Scomberomorus guttatus*); S3: snapper (*Lutjanus campechanus*); and S4: sardine (*Sardinella lemuru*)

Table 1. Results of Chemical, Physical, and Microbiological Analyses of Minced Fish Samples

No.	Type of Analysis	S1	S2	S3	S4
1	Moisture content (%)	81.86	80.33	77.28	63.04
2	Ash content (%)	0.89	0.89	1.89	2.24
3	Protein content (%)	13.93	11.23	12.22	10.66
4	Fat content (%)	0.98	2.01	1.69	1.22
5	Carbohydrate content (%)	0.69	6.35	3.28	12.19
6	pH	6.56	5.96	7.11	6.93
7	Total Plate Count (CFU/g)	1.6×10^7	2.2×10^7	1.7×10^7	2.8×10^7
8	Total Volatile Base Nitrogen (TVB-N, mg N/100 g)	6.00	6.40	7.20	7.60
9	Trimethylamine Nitrogen (TMA-N, mg N/100 g)	2.74	3.72	14.54	12.40

Table 2. Scoring Test Results of Minced Fish Samples

Sample	Scoring Test Score (Mean of 12 Panelists)			
	Appearance	Aroma	Texture	Overall
S1	7	7	7	7
S2	6	7	7	7
S3	7	7	7	7
S4	6	5	4	5

Table 3. Hedonic Test Results of Minced Fish Samples

Sample	Hedonic Test Score (Mean of 12 Panelists)			
	Appearance	Aroma	Texture	Overall
S1	7.5	7	7	7
S2	7	7	7	7
S3	7	6	6	7
S4	5	5	5	5

Discussion

The susceptibility of minced fish to rapid quality deterioration is well documented and is primarily attributed to increase oxygen exposure and microbial accessibility following mechanical

comminution (Suvanich et al., 2000; Huss, 1995;Özyurt et al., 2018; Huss, 2016). The observed variation in freshness parameters among minced fish samples reflects the combined influence of species-related biochemical characteristics and post-harvest handling practices. Mechanical mincing substantially increases the exposed surface area of muscle tissue, thereby accelerating biochemical reactions and microbial activity. As emphasized by previous study (Gram & Dalgaard, 2002), spoilage bacteria rapidly proliferate under such conditions, particularly when temperature control and sanitation are inadequate. The measured pH values in this study indicate that most samples were still within the early stages of quality deterioration, while the low TVB-N levels suggest that extensive protein degradation had not yet occurred.

Although TVB-N values remained within acceptable freshness ranges, elevated TMA-N levels observed in marine species indicate the onset of spoilage processes associated with bacterial reduction of trimethylamine oxide (TMAO). TMA-N has therefore been reported as a more specific indicator for freshness loss in marine fish compared to freshwater species (Dalgaard, 2014; Kim et al., 2023). Despite generally acceptable TVB-N values, elevated TMA-N concentrations in certain samples indicate the onset of spoilage processes, particularly in marine fish. This observation is consistent with the reduction of trimethylamine oxide, a compound naturally present in marine species and widely recognized as a specific indicator of marine fish spoilage (Blafsdbttir et al., 1997). However, the higher TMA-N values observed in spotted mackerel samples should not be interpreted as an inherent decline in quality associated with the species itself. Rather, these values are more plausibly linked to extrinsic factors such as handling conditions, temperature fluctuations, exposure time during processing, and sanitation practices at the market level. Previous studies have demonstrated that inappropriate post-harvest handling can accelerate spoilage in pelagic fish regardless of their intrinsic freshness potential (Arafah et al., 2025).

A critical concern identified in this study is the consistently high Total Plate Count across all samples. According to previous research (Gram & Dalgaard, 2002), high microbial loads in fish products are primarily driven by poor hygienic conditions during processing and distribution rather than by the initial quality of the raw material alone. Minced fish products are particularly vulnerable to microbial proliferation due to increased surface area and repeated contact with processing equipment and the surrounding environment. These findings explain why chemical freshness indicators may still appear acceptable while microbiological safety is already compromised. These findings clearly demonstrate that while sensory evaluation remains indispensable for assessing consumer acceptance, it is insufficient as a standalone indicator of product safety. This limitation is particularly critical for minced fish, where microbiological hazards may develop rapidly without causing immediate sensory rejection. Therefore, sensory testing should be systematically reinforced with chemical and microbiological analyses to strengthen the reliability of freshness assessment and safety conclusions (Grassi et al., 2023; Prabhakar et al., 2020).

Sensory evaluation results generally aligned with the physicochemical and microbiological findings. Samples exhibiting higher spoilage indicators tended to receive lower sensory scores, particularly for aroma and texture. Sardine samples (S4), characterized by higher ash and carbohydrate contents along with elevated TPC and TMA-N values, showed reduced aroma acceptance and softer texture, which was reflected in the lowest scoring and hedonic test results. This relationship supports earlier reports that sensory attributes such as odor and texture are among the earliest quality parameters perceived by consumers during spoilage (Blafsdbttir et al., 1997).

Conversely, snakehead (S1) and snapper (S3) maintained relatively favorable sensory attributes despite exhibiting high microbial counts. This outcome illustrates a critical limitation of sensory evaluation: consumer acceptance may persist during the early stages of microbial contamination. While sensory analysis remains essential for assessing market acceptability and consumer perception, it does not necessarily provide a reliable indication of microbiological safety. Similar conclusions have been reported by (Fadhallah et al., 2024), who emphasized that sensory assessment should be complemented by objective chemical and microbiological analyses to ensure food safety.

In addition to freshness and microbiological safety, the quality of minced fish is also critical for its subsequent utilization in processed products. Proper freshness control is essential not only to maintain sensory acceptability but also to minimize potential allergenic risks associated with protein

degradation and improper handling, as highlighted in recent studies on fish allergy management and processing technologies (Nasyiruddin et al., 2025).

Furthermore, high-quality minced fish serves as an important raw material for value-added products such as fish-enriched instant noodles. Previous research has demonstrated that the safety, freshness, and physicochemical stability of minced fish directly influence the nutritional quality and consumer acceptance of fish-based noodle products, particularly within sustainable and circular economy frameworks (Kılınç et al., 2025).

From a broader nutritional perspective, maintaining the quality of minced fish is also essential to support public health strategies promoting fish consumption. Community-based nutrition programs emphasize the importance of safe and high-quality fish products to improve dietary protein intake and prevent nutrition-related disorders, including stunting, particularly in developing regions (Nasyiruddin et al., 2024).

Implications

The findings underline the urgent need to improve hygiene practices, sanitation, and temperature management during the processing, handling, and sale of minced fish in traditional markets. Reliance on chemical freshness indicators or sensory acceptance alone may lead to underestimation of microbiological hazards, potentially exposing consumers to foodborne health risks.

Research Contribution

This study contributes to the existing body of knowledge by providing an integrated assessment of minced fish quality using chemical, microbiological, and sensory parameters. The results offer valuable baseline information on the safety and freshness of minced fish products sold in traditional markets, a context that remains underrepresented in international literature, particularly in developing regions.

Limitations

The study was limited by the number of fish species and sampling locations, which may not fully represent the variability of minced fish quality across different markets. In addition, the absence of detailed information on storage duration, temperature history, and vendor-specific handling practices may influence the interpretation of freshness and safety indicators.

Suggestions

Future research should involve a wider range of fish species, multiple market locations, and seasonal sampling to provide a more comprehensive evaluation. The inclusion of molecular microbiological techniques and hazard identification approaches is recommended to improve the detection of potential food safety risks. Furthermore, intervention-based studies focusing on improved sanitation, equipment hygiene, and cold-chain management are necessary to enhance the safety and quality of minced fish products in traditional market systems.

CONCLUSION

The freshness of minced fish sold in the studied traditional market varied depending on fish species and handling conditions. Chemical and physical indicators showed that most samples remained within acceptable freshness ranges, whereas microbiological analysis revealed high microbial loads that may compromise food safety. Sensory evaluation further indicated varying levels of consumer acceptance among the samples.

Taken together, these findings confirm that an integrated freshness evaluation is essential for minced fish products, as reliance on sensory acceptance or chemical indicators alone may underestimate microbiological risks, particularly under traditional market conditions. Accordingly, the results demonstrated that minced fish sold in traditional markets requires good handling

practices, especially with respect to sanitation and temperature control, to ensure product safety and quality.

Therefore, the application of integrated freshness evaluation parameters is strongly recommended as a fundamental basis for quality monitoring, risk mitigation, and consumer protection in traditional fish marketing systems.

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AUTHOR CONTRIBUTION STATEMENT

RLN[1], RLU[2], LPS[3], and ZHH[4] conceived and designed the study, conducted the main research activities, were responsible for data analysis and interpretation, and manuscript writing. SK[5] contributed to critical scientific input, discussion development, and manuscript writing and revision from an international research perspective. W[6] and MO[7] assisted in sample preparation, laboratory work, data collection, and sensory evaluation during the research implementation. All authors reviewed and approved the final manuscript.

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