

ANALYSIS OF THE SUITABILITY OF FROZEN SPINLESS MILKFISH IN XYZ SMES WITH THE SPC APPROACH

Israwati Syam^{a*}, Harianti^a, Awaluddin^a

^aBalik Diwa Institute of Maritime Technology and Business

Correspondent Author*: israwatisyamo4@gmail.com

Abstract

Frozen boneless milkfish is an innovative processed fishery product with high economic value, but product quality must be maintained to ensure food safety and competitiveness in the market. This study aims to analyze the suitability of frozen boneless milkfish quality at XYZ SMEs using the Statistical Process Control (SPC) approach. The quality parameters observed include sensory tests (color, aroma, taste, and texture), microbiological tests in the form of Total Plate Count (TLC), and measurements of the core temperature of the fish. The study used two storage methods, namely freezer and cold storage, with three storage periods (7, 14, and 21 days) and each was carried out three times. The results showed that all samples met the sensory quality standard with a value of ≥ 7 , the core temperature of the fish was in the range of $\leq -18^{\circ}\text{C}$, and the TLC value was still below the maximum limit of SNI, which is $\leq 5 \times 10^5$ colonies/g. However, the results of the SPC analysis using the X-chart and R-chart control charts showed several points outside the control limits, indicating that the production process was not yet fully statistically stable. This indicates that although product quality generally meets standards, variations in the production process still need to be controlled to maintain quality consistency between batches. Therefore, the implementation of continuous quality control and production process improvements are essential to improve process stability and product quality of frozen boneless milkfish.

Keywords: boneless milkfish; frozen fish products; quality control; statistical process control; microbial quality

Abstrak

Bandeng tanpa duri beku merupakan salah satu inovasi produk olahan perikanan yang memiliki nilai ekonomi tinggi, namun mutu produk harus dijaga untuk menjamin keamanan pangan dan daya saing di pasar. Penelitian ini bertujuan untuk menganalisis kesesuaian mutu bandeng tanpa duri beku pada UKM XYZ menggunakan pendekatan *Statistical Process Control* (SPC). Parameter mutu yang diamati meliputi uji sensori (warna, aroma, rasa, dan tekstur), uji mikrobiologi berupa Angka Lempeng Total (ALT), serta pengukuran suhu pusat ikan. Penelitian menggunakan dua metode penyimpanan, yaitu freezer dan *cold storage*, dengan tiga lama penyimpanan (7, 14, dan 21 hari) dan masing-masing dilakukan tiga kali ulangan. Hasil penelitian menunjukkan bahwa seluruh sampel memenuhi standar mutu sensori dengan nilai ≥ 7 , suhu pusat ikan berada pada kisaran $\leq -18^{\circ}\text{C}$, serta nilai ALT masih berada di bawah batas maksimum SNI yaitu $\leq 5 \times 10^5$ koloni/g. Namun, hasil analisis SPC melalui peta kendali \bar{X} -chart dan R-chart menunjukkan beberapa titik berada di luar batas kendali, yang mengindikasikan bahwa proses produksi belum sepenuhnya stabil secara statistik. Hal ini menunjukkan bahwa meskipun mutu produk secara umum telah memenuhi standar, variasi proses produksi masih perlu dikendalikan untuk menjaga konsistensi mutu antar batch. Oleh karena itu, penerapan pengawasan mutu secara berkelanjutan dan perbaikan proses produksi sangat diperlukan untuk meningkatkan stabilitas proses dan mutu produk bandeng tanpa duri beku.

Kata Kunci: ikan bandeng tanpa tulang; mutu mikrobiologis; pengendalian mutu; pengendalian proses statistik; produk ikan beku



INTRODUCTION

Milkfish (*Chanos chanos*) is one of the important aquaculture commodities in Indonesia's brackish waters which is widely cultivated in traditional and semi-intensive ponds because it has high economic value and production potential, (Ayuzar et al., 2021; Lustianto et al., 2020; Parikesit et al., 2025). South Sulawesi and several other coastal areas in Indonesia are known as milkfish production centers that contribute significantly to the national supply, so this commodity plays an important role as a source of animal protein as well as supporting household income of cultivators and fishery product processing business actors, (Hasiani & Ash'ari, 2024; Parikesit et al., 2025; Sulandjari et al., 2022).

However, like other fish commodities, milkfish is *perishable* due to its high water and protein content, so it is very susceptible to deterioration in quality and microbial contamination if not handled and processed properly, (Hasiani & Ash'ari, 2024; Masrifah et al., 2015; Putri et al., 2021). Research on fresh milkfish at Fish Auction Sites shows that unhygienic handling can lead to contamination of pathogenic bacteria such as *Salmonella* spp. and a high total number of microbes, so it does not meet SNI standards for fresh fish and has the potential to pose health risks to consumers, (Putra, 2022). On the other hand, studies on lead bioaccumulation (Pb) in traditional ponds show that the quality of the aquaculture environment also needs to be monitored to ensure the safety of milkfish raw materials, (Parikesit et al., 2025).

As production increases, the diversification of processed milkfish is an important strategy to increase added value, extend shelf life, and expand the fishery product market, (Hasiani & Ash'ari, 2024; Triyastuti et al., 2023; Wodi & Cahyono, 2022). Various service programs and economic studies prove that the processing of milkfish into products such as presto, bonbon, crackers, otak-otak, amplang, and various snacks can increase added value, income of business actors, and open new business opportunities for women's groups and coastal MSMEs, (Triyastuti et al., 2023; Wodi & Cahyono, 2022). The analysis of the added value of processing milkfish into amplang shows a high value-added ratio and significant profits, confirming that processing makes a much better economic contribution than just selling fresh fish, (Hasiani & Ash'ari, 2024). Similarly, assistance in the production of milkfish brains and milkfish crackers in various regions increases production capacity, sensory quality of products, and marketing capabilities, including the use of online media, (Aisyah et al., 2024; Ayuzar et al., 2021).

One of the fastest-growing processing innovations is the boneless milkfish product, which answers the main complaint of consumers about the large number of fine thorns in milkfish, (Raheni et al., 2024). Training on spineless milkfish processing in groups of women in Sulawesi and South Sulawesi shows that the spine removal technique allows milkfish to be processed into a more practical, safe, and easily accepted product for consumers of various age groups, (Sulandjari et al., 2022). Spineless milkfish products have the potential to enter a wider market segment, including hotels, restaurants, catering, and modern markets, especially when supported by attractive packaging, quality assurance, and digital marketing, (Hasiani & Ash'ari, 2024). In some areas, the use of more modern equipment such as meat and thorn separators has been proven to improve production efficiency, processing capacity, and consistency of raw material quality for various milkfish derivative products, (Sulandjari et al., 2022).

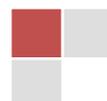
Food quality and safety are crucial aspects of processed fish products, considering that fish are highly susceptible to physical, chemical, and microbiological damage during the handling, processing, and distribution process (Ash'ari et al., 2024; Masrifah, 2015; Putri et al., 2021; Putra, 2022). A study on the SME-scale milkfish pindang processing unit shows that



organoleptic quality and chemical parameters can meet SNI if supported by the implementation of Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP) (Masrifah, 2015). However, an evaluation of several fish processing units and small businesses shows that there are still often irregularities related to sanitation, hygiene, production facilities, and process supervision that have the potential to reduce product quality and safety (Masrifah, 2015; Rizky et al., 2025; Putri et al., 2021; Putra, 2022; Widyastuti et al., 2025). Other research also confirms that fresh milkfish at the market level can be contaminated with pathogenic microbes when facilities and sanitation practices are inadequate, reinforcing the importance of strict quality control systems throughout the supply chain (Ginting et al., 2018; Rizky et al., 2025; Putri et al., 2021; Putra, 2022). This challenge is generally greater at the small and medium enterprises (SMEs) scale that still face technological limitations, trained human resources, and documented quality monitoring systems (Masrifah, 2015; Rizky et al., 2025; Putri et al., 2021; Widyastuti et al., 2025; Aisyah et al., 2024).

During increasing public awareness of food safety, nutrition, and quality consistency, milkfish processing business actors are required to not only produce varied and value-added products, but also meet the quality and safety standards required by regulations and markets (Ash'ari et al., 2024; Masrifah, 2015; Ginting et al., 2018; Rizky et al., 2025; Putri et al., 2021; Putra, 2022). Various studies on the development of processed fish products, both milkfish, tuna, and other commodities show that a combination of product diversification, improvement of hygienic processing techniques, and strengthening quality management can increase product competitiveness while supporting food security and blue economy at the local level (Ash'ari et al., 2024; Wodi & Cahyono, 2022; Triyastuti et al., 2023; Putri et al., 2021; Supardi et al., 2024; Musdar et al., 2023; Aisyah et al., 2024). In the context of SMEs, uncontrolled quality can cause quality variations between batches, market rejection, economic losses, and health risks for consumers, especially related to microbiological parameters such as Total Plate Count (ALT), *Escherichia coli*, *Salmonella*, and *Vibrio cholerae* which are often used as indicators of fish product safety, (Ginting et al., 2018). Therefore, systematic and data-based quality control is an urgent need, including for producers of milkfish without frozen spines.

One approach that can be used to monitor and control product quality in a structured manner is Statistical Process/Quality Control (SPC/SQC). In the food industry, SPC is used to analyze process variations, detect deviations beyond control limits, and identify the cause of product damage through control maps, check sheets, histograms, and cause-and-effect diagrams, (Setiawan et al., 2025). The application of this method to the fish canning industry, for example, shows that control maps can reveal product damage beyond the control limits and direct improvements to machinery, raw materials, methods, human, and environmental factors (Putri et al., 2021). In other small and medium-sized food businesses, SPCs are being adapted to assess process stability, reduce defective products, and improve quality consistency as part of efforts to increase added value and competitiveness (Rizky et al., 2025; Putri et al., 2021). Although initially widely applied in large-scale industries, this evidence suggests that SPC is relevant and can be implemented in food SMEs, including frozen spinless milkfish processing, to ensure that sensory and microbiological quality variations remain within acceptable limits and meet applicable food safety standards (Masrifah, 2015; Rizky et al., 2025; Putri et al., 2021; Putra, 2022; Widyastuti et al., 2025). Based on this explanation, the analysis of the suitability of the quality of milkfish without frozen spines with the SPC approach in SMEs is important to support business sustainability and consumer protection.



METHOD

This research was carried out using samples of frozen spinless milkfish products belonging to UKM Cahaya Bandeng in Maros Regency, with all tests carried out in the laboratory of the Makassar Fishery Product Quality Implementation Center (BPMPP). The research design involved two storage treatments (*freezer and cold storage*) with three storage periods (7, 14, and 21 days). The parameters observed included sensory tests (ice sheet, dehydration, discoloration, appearance, smell, and texture) using a hedonic scale of 1–9 by trained panelists referring to the practice of organoleptic tests of frozen and processed fish commonly used in cold/frozen fish quality research, (Iriani et al., 2022; Putalan et al., 2025; Putinur et al., 2025). Microbiological tests were carried out on the Total Plate Count (ALT) using the *pour plate method* referring to SNI 2332.3:2015, which is commonly used for the assessment of the microbiological quality of fresh and processed fish during cold or frozen storage, (Asha et al., 2024; Dewi et al., 2023). ALT data were statistically analyzed using the *Statistical Process Control* (SPC) approach using X-chart and R-chart control maps to assess process stability and microbiological quality variation as applied to the quality control of fishery products and other foods, (Dewi et al., 2023; Karki et al., 2020). The process capability is evaluated through the calculation of Cp, Cpk, CpL, and CpU indices based on the microbiological quality specification limits set in SNI 7316.1:2009 for frozen fish products, so that it can be assessed whether the frozen spine milkfish production process of Cahaya Milkfish SMEs is able to consistently meet applicable food safety standards, (Asha et al., 2024; Dewi et al., 2023; Putinur et al., 2025).

RESULT AND DISCUSSION

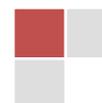
Quality control is an important aspect of the food production process to ensure that the products produced meet the quality standards that have been set and are safe for consumption. In the fish processing industry, especially frozen spinless milkfish products, quality consistency is a factor that greatly determines consumer confidence and product competitiveness in the market. Therefore, an analysis method is needed that can systematically monitor and evaluate the stability of the production process. One approach that can be used is *Statistical Process Control* (SPC), which is a statistical-based quality control method used to identify process variations and determine whether the production process is under control or not. Through this approach, the quality suitability of frozen spinless milkfish produced by XYZ SMEs can be analyzed so that an overview of the level of stability of the production process and potential quality deviations that occur can be obtained.

Sensory Test Results

Sensory tests showed that most samples had an average value of ≥ 7 , as per SNI requirements. However, there are two deviations: appearance (cold storage on day 21) and smell (cold storage on day 14) which is worth 6. This reflects the potential for damage or quality change due to too long storage or unstable temperatures. The following are the results of sensory tests of milkfish without frozen spines:

Table 1.
Sensory Test Results on Frozen Spinless Milkfish

Parameter	Sample						Quality Standards (SNI 7316.1:2009)
	F1	F2	F3	S1	S2	S3	
Ice Sheet	7,0	8,0	8,0	8,0	8,0	8,0	
Dehydration	9,0	9,0	8,0	9,0	9,0	9,0	Min.7



Discoloration	9,0	9,0	8,0	9,0	9,0	9,0
Appearance	7,0	7,0	7,0	7,0	7,0	6,0
Smell	7,0	7,0	7,0	7,0	6,0	7,0
Texture	7,0	7,0	8,0	7,0	7,0	8,0

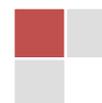
Source: research results, 2025

The results of sensory testing on milkfish without frozen spines showed that the average score in each parameter still met SNI 7316.1:2009 (≥ 7), so that the overall quality of the product was still decent. An ice sheet score of 7–8 indicates that the freezing and glazing process is still effective in protecting the surface of fish from fat oxidation and water loss, in line with the glazing function of other fish fillets which has been shown to suppress oxidation and maintain sensory quality during frozen storage, (Popelka et al., 2012). High dehydration and discoloration values (8–9) indicate that the physical condition of the product is still good, without over-drying or significant discoloration, indicating that the cold storage system used is still quite effective in maintaining quality stability, (Wereńska & Okruszek, 2023). However, the presence of a score of 6 on the appearance and smell of each sample reflects the beginning of a decrease in visual and aroma quality, which in frozen fish products is generally related to fat oxidation, gradual discoloration, uneven formation of ice crystals, and possible temperature fluctuations during the cold chain. This pattern is consistent with various other frozen fish studies that report a gradual decrease in appearance and odor scores during frozen storage, although the product is still considered acceptable to the panelists, (Nisperos et al., 2025a; Sveinsdóttir et al., 2020; Wereńska & Okruszek, 2023). Although the quality of frozen spineless milkfish still meets the standard and is acceptable to consumers, the findings of substandard scores on several parameters confirm the importance of stricter cold chain management, especially temperature stability and shelf-life restrictions, to maintain the sensory quality of the product and meet quality requirements.

Fish Center Temperature Test Results

The average product center temperature of around $-19\text{ }^{\circ}\text{C}$ (measure: $-19.7\text{ }^{\circ}\text{C}$) means that storage takes place below the commonly recommended maximum limit for frozen fish, which is around $-18\text{ }^{\circ}\text{C}$ as the standard commercial freezing temperature. Studies have shown that the lower the storage temperature below freezing, the slower the rate of fat breakdown (*lipid oxidation*), protein denaturation, and other chemical reactions that degrade the quality of the fish, (Liu et al., 2025; Suárez-Medina et al., 2024; Tolstorebrov et al., 2016; Wang et al., 2022). In the range of about -18 to $-20\text{ }^{\circ}\text{C}$, the growth of microorganisms is almost completely inhibited, and enzyme activity is greatly slowed down, so that physical and sensory qualities (texture, color, smell) can be maintained longer than regular cold storage (0 – $5\text{ }^{\circ}\text{C}$). (Duarte et al., 2020; Nisperos et al., 2025b; Suárez-Medina et al., 2024).

Studies on various processed fish products and fillets have shown that stable frozen storage at around $-18\text{ }^{\circ}\text{C}$ is able to maintain a quality that is still acceptable to consumers for weeks to months, although the quality gradually declines over the shelf life, (Shikha et al., 2021; Tsironi et al., 2020). In addition, temperature stability (minimal fluctuations) is a key factor in cold chain management, as the freeze–thaw cycle partially accelerates fat oxidation and tissue structure damage, (Shafi et al., 2020; Tsironi et al., 2020). Thus, the core temperature of frozen spineless milkfish in the range of $-19\text{ }^{\circ}\text{C}$ can be considered an indicator that the freezing process and storage management of SMEs has met the basic principles of frozen fishery product storage and contributes to maintaining the safety and consistency of product quality.



Results of the Total Plate Number Test (ALT)

The average ALT value of all treatments was 64.166 CFU/g. The highest value sample was the 14th day cold storage (87,333 CFU/g), and the lowest was the 21st day freezer (37,000 CFU/g). All ALT values were well below the SNI maximum limit (5×10^5 CFU/g), indicating that the microbiological quality is still safe. The following are the results of ALT testing of frozen spineless milkfish products:

Table 2.

Results of the ALT test on the product of the Styrofoam without thorns

Perlakuan	Sample			Average
	A	B	C	
Freezer (F1)	70.000	90.000	71.000	77.000
Freezer (F2)	36.000	89.000	68.000	64.333
Freezer r (F3)	35.000	39.000	37.000	37000
Cold storagei(S1)	83.000	90.000	71.000	81.333
Cold storagei(S2)	98.000	88.000	76.000	87.333
Cold storagei(S3)	38.000	37.000	39.000	38000

Source: research analysis results, 2025

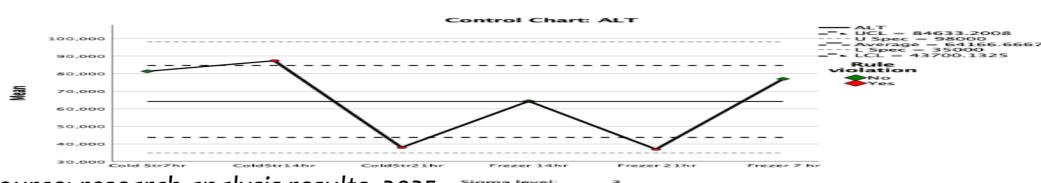
The results of the Total Plate Number (ALT) test on frozen spineless milkfish products showed an average value of 64,166 CFU/g, with the highest value on day 14 cold storage of 87,333 CFU/g and the lowest on day 21 of freezer of 37,000 CFU/g, reflecting the influence of temperature and storage time on the growth of microorganisms. Storage at lower temperatures such as freezers is more effective at suppressing microbial growth than cold storage, so the ALT value in the freezer is generally lower. All ALT values are still far below the maximum limit of SNI 7316.1:2009 which is 5×10^5 CFU/g for frozen fishery products, indicating that the product is safe and suitable for microbiological consumption. This condition also shows that the handling, processing, and storage processes applied can effectively inhibit the development of microorganisms, although temperature control and sanitation remain important to maintain product quality. Other studies also affirm the importance of temperature and hygiene control in maintaining the microbiological safety of frozen fish to avoid pathogens such as Salmonella spp. and other contaminants that can endanger consumer health, (Malimon et al., 2018; Ndobe et al., 2023; Sanjee & Karim, 2016). Therefore, well-stored frozen spineless milkfish products meet international and national microbiological safety standards.

Control Map and Capability Analysis

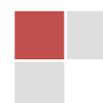
The X-chart shows most of the points are within the control limit (UCL: 84,633, LCL: 43,700), but there are three points that break out of this boundary: day 14 cold storage (high ALT), day 21 cold storage (poor appearance), and day 21 freezer (low extreme values can be seen in figure 1 below:

Figure 1.

X-bar ALT Control Chart of Frozen Boneless Milkfish Products under Various Storage Treatments



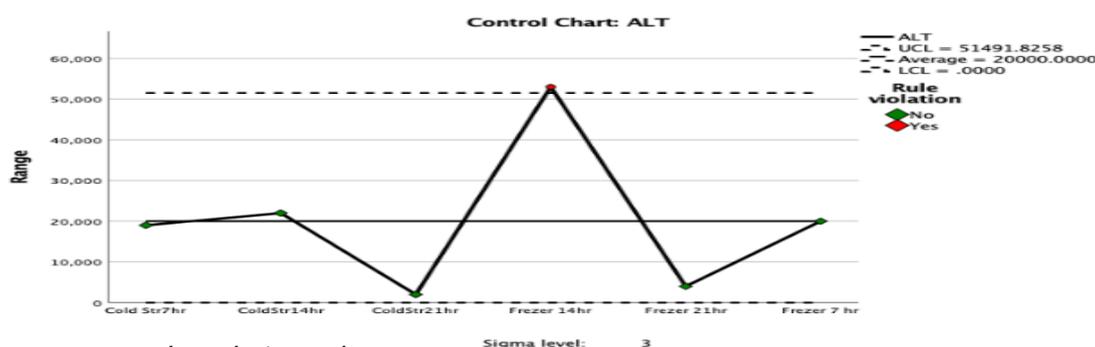
Source: research analysis results, 2025



The R-chart shows relatively good process stability. But in the results of the range analysis, it was seen that most of the variation values between repetitions were still within the specified control limits, but there was one point in the 14-day freezer treatment that exceeded the upper control limit. This shows that there is an inconsistency between the repetitions of the samples taken in the treatment. Too large a variation like this can be caused by the actual temperature difference between the product positions in the storage space, the unequal handling time or the difference in the sanitation of the appliance in each batch. The test results can be seen in the picture below:

Figure 1.

X-bar ALT Control Chart of Frozen Boneless Milkfish Products under Various Storage Treatments



Source: research analysis results, 2025

Indeks Kapabilitas Proses, yaitu $C_p = 0,889 \rightarrow$ proses relatif bervariasi; $C_{pk} = 0,823 \rightarrow$ sedikit di bawah nilai ideal (1,33); $C_{pL} = 0,823$ dan $C_{pU} = 0,954$ menunjukkan lebih mendekati batas atas. Hasil uji statistik kapabilitas proses dapat dilihat pada tabel dibawah ini:

Table 3.

Results of ALT Process Capabilities of Frozen Spinless Milkfish Products

Capability Index	Value	Information
C_p	0,889	Demonstrates general process capability over a specification range
C_{pL}	0,823	Process capability against lower specification limit (LSL)
C_{pU}	0,954	Process capability against upper specification limit (USL)
C_{pk}	0,823	Actual process capability index (referring to the weakest side: C_{pL})
LSL	35.000 CFU/g	Lower limit of microbiological quality specification for ALT parameter
USL	98.000 CFU/g	Upper limit of microbiological quality specifications (ALT)

Source: research analysis results, 2025

The C_{pk} value of < 1 indicates that some parts of the process are still not fully in accordance with quality specifications, especially related to temperature control and hygiene of the production environment.

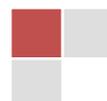


CONCLUSION

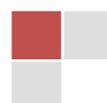
Based on the results of the study on the quality of frozen spinless milkfish products in UKM XYZ using the Statistical Process Control (SPC) approach, it can be concluded that in general the product quality from the sensory aspect has met the SNI 7316.1:2009 standard, especially in the parameters of ice sheet, dehydration, discoloration, texture, and odor, although there is a decrease in quality in some samples such as S2 (odor) and S3 (appearance) which are below the minimum sensory standard values. The central temperature of the product is also still within the set standard limits. From a microbiological aspect, the Total Plate Number (ALT) value of the entire treatment is still far below the maximum permissible limit of 5×10^5 CFU/g, with an average value range of 37,000–87,333 CFU/g. However, the results of the SPC analysis showed that there were several violations of the control limits that indicated that the production and storage processes were not yet fully statistically stable. This is strengthened by the value of process capability ($C_p = 0.889$ and $C_{pk} = 0.823$) which shows that the process still has a high enough variation, so improvements are needed in the control of the production process and storage system so that product quality can be produced more consistently in accordance with the set specifications.

REFERENCES

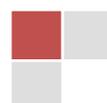
- Aisyah, S., Putra, A. L. T., Sari, S. F., Desmiati, I., Rustam, D., & Munzir, A. (2024). Optimalisasi Diversifikasi Produk Perikanan Untuk Ketahanan Pangan Dan Peningkatan Blue Economy: Inisiatif Keterlibatan Masyarakat Lokal. *Jurnal Pemberdayaan Sosial Dan Teknologi Masyarakat*, 4(2), 204.
- Asha, N. A., Syukroni, I., & Tasir, T. (2024). Efikasi Bakterostatik Kulit Bawang Merah Pada Ikan Bandeng (*Chanos chanos*) Selama Penyimpanan Suhu Ruang. *Jambura Fish Processing Journal*. <https://doi.org/10.37905/jfpj.v6i2.25104>
- Ayuzar, E., Muliani, M., Adhar, S., & Rahman, A. (2021). Teknik pembuatan kerupuk bawang ikan bandeng (*Chanos chanos*) untuk pemberdayaan perempuan di Gampong Ulee Pulo Kabupaten Aceh Utara (Processing techniques of onion crackers from milk fish (*Chanos chanos*) for women empowerment at Ulee Pulo Village District of Aceh Utara). *Buletin Pengabdian*, 1(1), 7–11.
- Dewi, E. K., Surilayani, D., & Pratama, G. (2023). Pengaruh Metode Pengemasan Abon Ikan Bandeng (*Chanos chanos*) Terhadap Perubahan Mutu Produk Selama Penyimpanan Suhu Ruang. *Jurnal Pascapanen Dan Bioteknologi Kelautan Dan Perikanan*. <https://doi.org/10.15578/jpbkp.v18i1.891>
- Duarte, A., Silva, F., Pinto, F., Barroso, S., & Gil, M. (2020). Quality Assessment of Chilled and Frozen Fish—Mini Review. *Foods*, 9. <https://doi.org/10.3390/foods9121739>
- Ginting, S. S. B., Suryanto, D., & Desrita, D. (2018). Isolasi dan karakterisasi bakteri potensial probiotik pada saluran pencernaan ikan bandeng (*Chanos chanos*). *Acta Aquatica: Aquatic Sciences Journal*, 5(1), 23–29.
- Hasiani, Y., & Ash'ari, F. M. (2024). Penerapan Metode Hayami dalam Analisis Nilai Tambah Pengolahan Ikan Bandeng Menjadi Amplang. *Rawa Sains: Jurnal Sains STIPER Amuntai*, 14–20.
- Iriani, D., Leksono, T., & Hutahayan, W. R. B. (2022). Pengaruh Penambahan Jahe Merah (*Zingiber officinale* var. *rubrum*) Terhadap Mutu Organoleptik dan Biokimia Ikan



- Bandeng (*Chanos chanos*) Presto Selama Penyimpanan Dingin. *Jurnal Teknologi Dan Industri Pertanian Indonesia*. <https://doi.org/10.17969/jtipi.v14i2.22807>
- Karki, S., Chowdhury, S., Nath, S., & Dora, K. (2020). Freezing effects on yield, quality, and microbial load of farmed fish *Neolissochilus hexagonolepis* (Chocolate Mahseer). *Journal of Entomology and Zoology Studies*. <https://doi.org/10.22271/j.ento.2020.v8.i6ab.8124>
- Liu, R., Tan, C., Tu, Z., Nie, S., Yu, Y., Hu, J., & Zhang, L. (2025). Research progress on the mechanism of fish quality deterioration during frozen storage and novel control technologies. *Food Science of Animal Products*. <https://doi.org/10.26599/fsap.2025.9240105>
- Lustianto, A. F., Anggoro, S., & Widyorini, N. (2020). Pola Osmoregulasi, Kebiasaan Makanan dan Faktor Kondisi Ikan Bandeng (*Chanos Chanos*) di Tambak Desa Bakaran Wetan, Pati Osmoregulation Pattern, Food Habits and Milkfish Condition Factors (*Chanos chanos*) in Traditional Ponds Bakaran Wetan Village, Pati. *Management of Aquatic Resources Journal (MAQUARES)*, 9(1), 81–89.
- Malimon, Z., Kukhtyn, M., & Perkiy, Y. (2018). Contamination of frozen fish with mesophilic and psychrotrophic microorganisms depending on biochemical quality indice. *Theoretical and Applied Veterinary Medicine*. <https://doi.org/10.32819/2018.63008>
- Masrifah, E., Noorachmat, B. P., Sukmawati, A., & Pertanian, F. T. (2015). Kesesuaian penerapan manajemen mutu ikan pindang bandeng (*Chanos chanos*) terhadap Standar Nasional Indonesia. *Manajemen IKM*, 10(2), 163–172.
- Ndobe, S., Merpati, E. O., Rusaini, R., Serdiati, N., & Rusdi, R. (2023). Total plate count and *Salmonella* spp. in de-boned milkfish (*Chanos chanos*) in Palu City, Indonesia. *Depik*. <https://doi.org/10.13170/depik.12.2.30959>
- Nisperos, G. M., Hontiveros, G., Mandario, E. J., & Balandan, L. F. (2025a). Chemical Composition and Storage Stability of Dolphinfish (*Coryphaena* spp.) Siomai from Kiamba, Sarangani Province under Chilled and Frozen Conditions. *Asian Journal of Fisheries and Aquatic Research*. <https://doi.org/10.9734/ajfar/2025/v27i3898>
- Nisperos, G. M., Hontiveros, G., Mandario, E. J., & Balandan, L. F. (2025b). Chemical Composition and Storage Stability of Dolphinfish (*Coryphaena* spp.) Siomai from Kiamba, Sarangani Province under Chilled and Frozen Conditions. *Asian Journal of Fisheries and Aquatic Research*. <https://doi.org/10.9734/ajfar/2025/v27i3898>
- Parikesit, P. A., Dewi, N. N., Hidayati, N. V., Octoriani, W., & Andriyono, S. (2025). A Studi Komparasi Bioakumulasi Logam Berat Timbal (Pb) Pada Tambak Tradisional Ikan Bandeng (*Chanos Chanos*) Di Pantura Jawa Timur: Gresik, Sidoarjo, Dan Pasuruan. *Journal of Aquatropica Asia*, 10(1), 85–93.
- Popelka, P., Luptáková, O., Marcinčák, S., Nagy, J., Mesarčová, L., & Nagyová, A. (2012). The effect of glaze and storage temperature on the quality of frozen mackerel fillets. *Acta Veterinaria Brno*, 81, 397–402. <https://doi.org/10.2754/avb201281040397>
- Putalan, R., Imran, M., Farid, F., Nusi, F., Mi'raz, N., & Ariany, S. (2025). Pengaruh Metode Penanganan Pascapanen Dan Suhu Simpan Terhadap Mutu Proksimat Dan Organoleptik



- Ikan Nike (*Awaous melanocephalus*). *Jambura Fish Processing Journal*.
<https://doi.org/10.37905/jfpj.v7i2.33388>
- Putinur, P., Roiska, R., Wulandari, W., Hasanah, H., Arbajayanti, R. D., & Bareta, A. R. (2025). Mutu Organoleptik, Kimia dan Mikrobiologi Ikan Selar (*Caranx leptolepis*) yang Disimpan pada Suhu Ruang, Dingin dan Beku. *Jurnal Fishtech*.
<https://doi.org/10.36706/fishtech.v14i1.23660>
- Putra, L. V. D. (2022). Deteksi cemaran bakteri *Salmonella* spp. pada Ikan bandeng segar (*Chanos chanos*) di Tempat pelelangan ikan Gadukan Lumpur Kabupaten Gresik. *Bioscientist: Jurnal Ilmiah Biologi*, 10(2), 881–890.
- Putri, M. A., Chameloza, C., & Anggriani, R. (2021). Analisis pengendalian kualitas produk pengalengan ikan dengan metode statistical quality control (studi kasus: pada CV. Pasific Harvest). *Food Technology and Halal Science Journal*, 4(2), 109–123.
- Raheni, C., Putra, S. M., Umar, U., Hak, N., Mutmainah, M., Mande, H., Burhanuddin, B., & Kasih, U. C. (2024). Pendampingan Pengolahan Ikan Bandeng (*Chanos Chanos*) Tanpa Duri Pada Kelompok Wanita Di Kelurahan Talise Kota Palu. *Arunika: Jurnal Pengabdian Masyarakat*, 3(1), 1–10.
- Sanjee, S. Al, & Karim, Md. E. (2016). Microbiological Quality Assessment of Frozen Fish and Fish Processing Materials from Bangladesh. *International Journal of Food Science*, 2016.
<https://doi.org/10.1155/2016/8605689>
- Setiawan, H. R. O. S., Sinaga, A. E., Hidayat, A. S., Al Ghifari, A. I., & Khalisha, N. H. (2025). Penerapan Model IPO dan Metode SPC Dalam Pengendalian Mutu Untuk Peningkatan Nilai Tambah di Maya Wortel, Kabupaten Sukabumi. *JURNAL AGRIBISNIS*, 14(1), 62–72.
- Shafi, J., Waheed, K., Zafarullah, M., Mirza, Z., & Yaqoob, S. S. (2020). Effect of icing on quality of silver carp during frozen storage. *Journal of Food Processing and Preservation*, 44.
<https://doi.org/10.1111/jfpp.14654>
- Shikha, F., Hossain, M., & Ali, M. (2021). Storage Effects of Low Temperature on the Quality Parameters of Mince Based Fish Stick Prepared from Silver Carp (*Hypophthalmichthys molitrix*). *Journal of Environmental Science and Natural Resources*, 12, 175–180.
<https://doi.org/10.3329/jesnr.v12i1-2.52033>
- Suárez-Medina, M., Sáez-Casado, M., Martínez-Moya, T., & Rincón-Cervera, M. (2024). The Effect of Low Temperature Storage on the Lipid Quality of Fish, Either Alone or Combined with Alternative Preservation Technologies. *Foods*, 13.
<https://doi.org/10.3390/foods13071097>
- Sulandjari, K., Abubakar, A., & Agustina, D. (2022). Penyuluhan pengolahan ikan bandeng menjadi aneka produk olahan dalam rangka meningkatkan pendapatan masyarakat desa Karyamakmur. *Abdi Masyarakat*, 4(2), 178–186.
- Sveinsdóttir, H., Karlsdóttir, M., Arason, S., Stefánsson, G., Sone, I., Skåra, T., Rustad, T., Larsson, K., Undeland, I., & Gudjónsdóttir, M. (2020). Effect of antioxidants on the sensory quality and physicochemical stability of Atlantic mackerel (*Scomber scombrus*) fillets during frozen storage. *Food Chemistry*, 321, 126744.
<https://doi.org/10.1016/j.foodchem.2020.126744>



- Tolstorebrov, I., Eikevik, T., & Bantle, M. (2016). Effect of low and ultra-low temperature applications during freezing and frozen storage on quality parameters for fish. *International Journal of Refrigeration-Revue Internationale Du Froid*, 63, 37–47. <https://doi.org/10.1016/j.ijrefrig.2015.11.003>
- Triyastuti, M. S., Ndahawali, D. H., Ondang, H. M., & Wijaya, N. (2023). Diversifikasi Olahan Produk Perikanan “Dimsum Tuna” Bagi Ibu Pembinaan Kesejahteraan Keluarga. *JMM (Jurnal Masyarakat Mandiri)*, 7(5), 4702–4711.
- Tsironi, T., Stoforos, N., & Taoukis, P. (2020). Quality and Shelf-Life Modeling of Frozen Fish at Constant and Variable Temperature Conditions. *Foods*, 9. <https://doi.org/10.3390/foods9121893>
- Wang, H., Shi, W., & Wang, X. (2022). Establishment of quality evaluation method for frozen tilapia (*Oreochromis niloticus*) fillets stored at different temperatures based on fractal dimension. *Journal of Food Processing and Preservation*. <https://doi.org/10.1111/jfpp.16421>
- Wereńska, M., & Okruszek, A. (2023). Impact of frozen storage on some functional properties and sensory evaluation of goose meat. *Poultry Science*, 102. <https://doi.org/10.1016/j.psj.2023.102894>
- Wodi, S. I., & Cahyono, E. (2022). Penerapan diversifikasi produk hasil perikanan sebagai upaya meningkatkan konsumsi ikan masyarakat kampung birahi kecamatan tabukan selatan. *Jurnal Ilmiah Tatengkorang*, 6(1), 1–6.

