

## FOOD SAFETY OF PROCESSED CRISPY COBIA (*Rachycentron canadum*) PRODUCTS IN A MICRO, SMALL AND MEDIUM ENTERPRISE IN PROBOLINGGO CITY

Keamanan Pangan Produk Olahan Ikan Jenggelek (*Rachycentron canadum*) Crispy pada UMKM di Kota Probolinggo

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### ABSTRACT

Small fishery businesses in Probolinggo increasingly turn cobia (*Rachycentron canadum*) into a crispy snack, yet little is known about how they manage food safety when they buy fish already dried by others instead of processing their own catch. This study assessed the food safety of that product at UD. Hamid Jaya, a family business trading as Dasugi Foods, looking at prerequisite programmes, the HACCP plan, microbial and chemical hazards, nutritional and sensory quality, and how neighbours view the business. Data came from observation, owner interviews, accredited laboratory tests, an eight-member sensory panel and a Likert questionnaire answered by 36 neighbours. Against the CPPB-IRT checklist, the business ranked at IRTF Level II (two major, one minor deviation). The hazard analysis yielded three critical control points: acceptance of the dried fish, deep-frying at 175 °C or hotter for 3 min or longer, and storage of the packed snack at relative humidity of 65% or below. The purchased fish exceeded the national plate count limit (SNI 8273:2016), and no *Salmonella* spp., pyrethroids or formaldehyde were found, but total arsenic (0.697 mg/kg) was about 2.8 times the BPOM limit of 0.25 mg/kg, and its inorganic share was not measured. Each 100 g of snack supplied 457 kcal and 39.7% protein at 3.27% moisture, the panel scored it 8.03 out of 9, and neighbours rated the business favourably (4.12 of 5). Because the main hazards arrive with the raw material, supplier checks, written HACCP records and routine metal testing deserve priority.

**Keywords:** Dried Fish, Food Safety, HACCP, MSME, *Rachycentron canadum*

### ABSTRAK

Usaha perikanan kecil di Kota Probolinggo makin banyak mengolah ikan jenggelek (*Rachycentron canadum*) menjadi camilan crispy, tetapi cara usaha tersebut mengelola keamanan pangan belum banyak diketahui, khususnya ketika ikan dibeli dalam keadaan sudah kering dari pihak lain. Penelitian ini menilai keamanan pangan produk tersebut di UD. Hamid Jaya, usaha keluarga bermerek Dasugi Foods, dari sisi program prasyarat, rencana HACCP,

bahaya mikroba dan kimia, mutu gizi dan sensori, serta tanggapan warga. Data dihimpun melalui observasi, wawancara dengan pemilik, analisis di laboratorium berakreditasi (ISO/IEC 17025), penilaian sensori oleh delapan orang panelis, dan kuesioner Likert kepada 36 warga sekitar. Berdasarkan daftar periksa CPPB-IRT, usaha ini tergolong IRTTP Level II; ditemukan dua temuan mayor dan satu temuan minor. Dari analisis bahaya ditetapkan tiga CCP: saat ikan kering diterima, penggorengan pada suhu minimal 175 °C selama sekurang-kurangnya 3 menit, dan penyimpanan produk kemasan pada kelembapan relatif paling tinggi 65%. Angka lempeng total ikan kering berada di atas ambang SNI 8273:2016; *Salmonella* spp., piretroid, dan formaldehida tidak ditemukan, sedangkan kadar arsen total (0,697 mg/kg) melampaui batas BPOM 0,25 mg/kg, kira-kira 2,8 kali lipat, sedangkan bentuk anorganiknya belum diuji. Tiap 100 g produk menyumbang 457 kkal, kadar protein 39,7%, dan air hanya 3,27%; panelis memberi nilai rata-rata 8,03 dari 9, dan warga menilai usaha ini positif (4,12 dari 5). Karena bahaya utama masuk bersama bahan baku, pemeriksaan pemasok saat penerimaan, pencatatan HACCP tertulis, dan uji logam berat rutin perlu didahulukan pada usaha sejenis.

**Kata Kunci:** HACCP, Ikan Kering, Keamanan Pangan, *Rachycentron canadum*, UMKM

## INTRODUCTION

In Indonesia, fish feed people and pay wages. Turning raw catch into processed goods raises its selling price and brings jobs to coastal towns, and even by-products can be converted into saleable items (Vanany et al., 2024). Probolinggo City, on the northern coast of East Java, depends to a large degree on marine and fisheries activity and has been one of the sites of the regional blue economy programme, which links processed fishery products to the creative economy (Marwiyah & Lailatul Fitria, 2023). Coastal processors, most of them micro, small and medium enterprises (MSMEs), can raise the added value of their products through better packaging and marketing (Hafiludin et al., 2025).

MSMEs absorb much of the Indonesian workforce and contribute to the national economy (Hapsari et al., 2024), so helping those built on local fish is a practical route to wider markets and better household income. Cobia (*Rachycentron canadum*), known locally as *ikan jenggelek*, is one of the species now being promoted in Probolinggo. Cobia grows fast and is now farmed in many countries (Benetti et al., 2021). The flesh is protein-rich and contains omega-3 fatty acids, which suits it to value-added foods (Ilhami & Nisak, 2025); fish in general are a key dietary source of animal protein, EPA and DHA (Andhikawati et al., 2021). Cobia is already processed industrially into frozen skinless fillets (Purnamasari et al., 2023), its bones and skin have been tested as gelatin sources (Anandito et al., 2024; Febrianti et al., 2023), and it passes through Mayangan Port in Probolinggo (Setyohadi et al., 2024). Local MSMEs mostly sell it as crispy cobia: pieces of dried fish dipped in spiced batter and deep-fried.

Ready-to-eat snacks of this kind must be safe without further cooking at home. In Indonesia, a fish processing unit needs to show GMP and SSOP in place before it can be granted a processing feasibility certificate (Permen KP, 2019). HACCP then builds on these prerequisites as a preventive system that finds and controls biological, chemical and physical hazards along the whole process (Codex Alimentarius Commission, 2020). Evidence from seafood plants suggests that firms complying with several safety standards, and using physical intervention steps, perform better on food safety (Van Durme et al., 2024). Small-scale fisheries, by contrast, often lack proper sanitation facilities, monitoring programmes and trained staff (Garrido Gamarro et al., 2023), and poor management and insufficient training are the main barriers to HACCP certification in the meat industry, with smaller firms facing added resource limits (Dima et al., 2024). Recent bibliometric work confirms that HACCP is still the backbone of quality management research in food production (Radu et al., 2023).

What sets UD. Hamid Jaya apart from the enterprises usually studied is its supply model. The owner does not dry fish on site; cobia arrives already dried from outside suppliers. Many microbial and chemical risks are therefore brought in at the gate rather than created in the kitchen, and the owner has little say over how the fish was handled beforehand. The concern is real, as an Indonesian survey found heavy metals above permitted levels in fish from polluted waters such as the Ciliwung River and Jakarta Bay (Yulyana *et al.*, 2023). This study therefore set out to evaluate the food safety of crispy cobia made by this MSME: to describe how its prerequisites (GMP and SSOP) and HACCP plan work in practice, to measure microbial and chemical hazards in the raw material and the snack, to report the nutritional and sensory quality of the product, and to record how neighbours perceive the business.

## RESEARCH METHODS

### Time and Location

Fieldwork ran from 1 April to 31 May 2026 at the premises of UD. Hamid Jaya in Probolinggo City, East Java. The area has busy fishing and processing activity and is one of the places where cobia products are being developed.

### Materials and Tools

Two materials were studied: the finished crispy cobia and the dried cobia that UD. Hamid Jaya buys to make it (Figure 1). Species identity was checked on fresh specimens at the supplier before drying, using external morphological characters. All laboratory work was carried out by PT Eurofins Angler Biochemlab in Surabaya, which holds ISO/IEC 17025:2017 accreditation from the national accreditation body (LP-514-IDN). Field instruments were a five-point Likert questionnaire, a hedonic score sheet (1–9) prepared according to SNI 2346:2015 (BSN, 2015), a digital thermometer and a hygrometer.



Figure 1. Packed crispy cobia sold under the Dasugi Foods brand.

### Research Design

This was a descriptive study with a mixed-methods design, carried out as a case study of one enterprise, UD. Hamid Jaya. Four data components were used, and each had a defined role. (1) A qualitative assessment of GMP, SSOP and HACCP practice, based on interviews, direct observation and the CPPB-IRT checklist, described the prerequisite programmes and the process flow and identified the hazards at each step. (2) Laboratory tests on the dried fish and the finished snack (microbial, chemical, heavy-metal and proximate analysis) measured those hazards against national limits. The food safety conclusions rest on these two components, which were integrated in three steps: the hazards identified in (1) were set against the laboratory results in (2); the steps at which a significant hazard was confirmed were designated CCPs with a decision tree; and critical limits, monitoring and corrective actions were then set for each CCP. (3) The sensory test and (4) the community questionnaire were not used to judge safety. They describe product acceptability and the social acceptance of the business, and they were interpreted alongside the safety findings in the Discussion, so that safety, acceptability and social acceptance can be read together without being merged into a single score.

The population for the community component was the 60 residents living within 500 m of the premises. Sampling was purposive, a non-probability approach in which participants are selected against stated criteria (Campbell *et al.*, 2020). Residents were eligible if they (1) lived within 500 m of the premises, (2) knew the business or had taken part in its activities, and (3) were willing to complete the questionnaire. These criteria were set because only residents with some contact with the business can judge its social and economic effects. The researcher visited and listed all 60 residents; 36 were willing to complete the questionnaire and 24 declined, a participation rate of 60% (36 of 60). The instrument had ten five-point Likert items and was administered face to face by the researcher, who explained how to fill it in. Participants were not compared with non-participants, and selection depended on willingness to take part and on contact with the business, so the results describe the views of residents who know it and are not representative of the whole neighbourhood. The likely direction of this bias is discussed under Social Acceptance.

Information on GMP, SSOP and HACCP practice was obtained by interviewing the owner and the staff involved in operations, and it was not accepted on their word alone. Each statement was checked against direct observation by the researcher during five visits to the premises between 1 April and 31 May 2026, against the written records that were available (for example, supplier paperwork and batch records), and against photographs taken during production (Figure 2). The CPPB-IRT checklist was scored from what was observed on the premises. Where a practice was described but no record or observation supported it, as with batch records (Table 1), it was graded on the evidence available and the owner's statement is reported as such. Laboratory results on the raw material and the snack gave an independent check on the hazards described. Combining interviews, observation, records and laboratory data in this way follows the principle of triangulation (Jespersen & Wallace, 2017).

#### **HACCP Plan and Prerequisite Programmes**

Prerequisite programmes were scored with the CPPB-IRT checklist. Each deviation was graded as minor, major, serious or critical, and the pattern of deviations sets the IRTP level, from I (best) to IV (BPOM, 2012). Businesses at level I or II can obtain the home-industry food production certificate (BPOM, 2018b). The HACCP plan followed the twelve steps in Codex CXC 1-1969 Rev. 2020 (Codex Alimentarius Commission, 2020). The process was mapped from receipt of the dried fish through sorting, washing, seasoning, battering, frying, draining, packing and storage to distribution (Figure 2). Biological, chemical and physical hazards were listed for every step, CCPs were identified with a decision tree adapted from Kosasih *et al.* (2025), and critical limits, monitoring procedures and corrective actions were set for each CCP.



Figure 2. Receiving, seasoning, frying and packing of crispy cobia at UD. Hamid Jaya.

#### **Laboratory Analysis**

Proximate analysis followed SNI 01-2891-1992 (BSN, 1992), the established Indonesian standard test method for food and beverages that was applied by the laboratory : protein by

Kjeldahl (clause 7.1), fat by Soxhlet (clause 8.2), and moisture and ash by gravimetry. Carbohydrate was obtained by difference, energy was calculated, and salt was titrated. Bifenthrin, cypermethrin and formaldehyde were measured by LC-MS/MS. Indonesia has no SNI limit for pesticide residues in fish, since SNI 7313:2008 covers only plant-based farm produce (BSN, 2008), so pesticide results were judged against the laboratory limit of quantification of 0.01 mg/kg. Cadmium, lead, total arsenic, total mercury and tin were quantified by ICP-MS, a technique widely used for multi-element analysis of fishery products (Kim *et al.*, 2023), and checked against BPOM Regulation No. 5 of 2018 (BPOM, 2018a), which sets limits of 0.25, 0.20, 0.10 and 0.50 mg/kg for arsenic, lead, cadmium and mercury in fish and fishery products and sets no limit for tin in this category. Aerobic plate count was determined by the laboratory with the FDA Bacteriological Analytical Manual method, Chapter 3 (U.S. Food and Drug Administration, 2026), and compared with SNI 8273:2016 (BSN, 2016), which allows at most  $1 \times 10^5$  colonies/g in dried salted fish. *Salmonella* spp. was screened by real-time PCR, and both parameters were also checked against BPOM Regulation No. 13 of 2019 (BPOM, 2019), category 09.2.5 (dried fish), which requires *Salmonella* to be negative in 25 g and sets  $1 \times 10^5$  and  $1 \times 10^6$  colonies/g as the lower and upper plate count limits, with up to two of five samples allowed between them. Samples were sent straight to the laboratory to keep the chain of custody intact (Figure 3).



Figure 3. Dried and crispy cobia samples being dispatched to the laboratory in Surabaya.  
**Sensory Evaluation**

The sensory panel consisted of eight semi-trained officers of the Jember Regency Food Security and Livestock Service who work as junior food security analysts or junior agricultural product quality inspectors. They scored appearance, odour, taste and texture on the 1-9 hedonic scale of SNI 2346:2015 (BSN, 2015), where any score above 7 means the product is liked (Figure 4). Before testing, the panelists were briefed on how to score fishery products. Each received the sample in an identical container labelled with a random three-digit code, so that scores would not be influenced by labels or by presentation order. All panelists were tested at the same time in a well-lit room free of foreign odours, and each recorded scores on a prepared score sheet. The panelists knew which product they were assessing, so the test was not blind; the random code only guarded against label and order effects. Only one product was assessed, so there was no serving order between products and no reference sample. Scores are reported as the mean and standard deviation of the eight panelists for each attribute.



Figure 4. Panelists scoring crispy cobia during the sensory test.

### Data Analysis

Laboratory and sensory results are reported as mean  $\pm$  standard deviation and compared with the relevant SNI and BPOM limits. Questionnaire answers were processed in SPSS with descriptive frequency statistics: a mean and standard deviation for each item, an overall grand mean, and the allocation of each respondent's total score to one of five bands, from "very poor" to "very good". The questionnaire had ten items, each answered on a five-point scale from 1 (very poor) to 5 (very good): social facilities provided by the business, involvement of local people in its development, acceptance of migrant workers, benefits from the business, absence of disturbance to safety and comfort (a high score means no disturbance), relations with neighbours, effect on the local economy, outlook for the business, general opinion of the business, and its effect on social life around it. The total score therefore ranged from 10 to 50, and the five bands were roughly equal intervals of eight points: very poor (10–18), poor (19–26), neutral (27–34), good (35–42) and very good (43–50).

## RESULTS

### GMP and SSOP Assessment

The work area was kept clean, the equipment was free of rust, raw fish and finished snacks were stored apart, and workers followed hygiene rules. Scored with the CPPB-IRT checklist, the business reached IRTP Level II, with two major deviations (building surfaces and batch records) and one minor deviation (cleaning routine), as shown in Table 1.

Table 1. CPPB-IRT findings on prerequisite programmes at UD. Hamid Jaya

| Aspect assessed                       | Observation                                     | Type of deviation |
|---------------------------------------|-------------------------------------------------|-------------------|
| Floor, walls, ceiling and ventilation | Surfaces not fully watertight; hard to sanitise | Major             |
| Batch and quality records             | Not written for every production batch          | Major             |
| Cleaning of work area and tools       | Carried out, but not yet a fixed routine        | Minor             |
| Resulting IRTP level                  | Level II                                        | –                 |

Source: field observation scored with the CPPB-IRT checklist (BPOM, 2012).

### HACCP Plan

Ten steps make up the process, from receipt of the dried fish to distribution (Figure 2). Drying is not one of them, because the fish is delivered dry. When the hazards at each step were set against the laboratory findings, three steps qualified as CCPs: receipt of the dried fish (CCP-1), deep-frying (CCP-2) and storage of the packed snack (CCP-3). Their hazards and critical limits are listed in Table 2. Monitoring was kept simple: a digital thermometer for oil temperature, a hygrometer in the store room, and a sensory check plus supplier paperwork for every delivery. When a limit is breached, the fish is returned to the supplier, the batch is fried again, or the stock is moved to a drier room.

Table 2. Critical control points in the HACCP plan for crispy cobia at UD. Hamid Jaya

| CCP   | Process step            | Hazard of concern                                            | Critical limit                                                                                                                                                                     |
|-------|-------------------------|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CCP-1 | Receipt of dried fish   | Biological: high plate count;<br>Chemical: arsenic           | Plate count $\leq 1 \times 10^5$ CFU/g;<br><i>Salmonella</i> absent; As $\leq 0.25$ , Pb $\leq 0.20$ , Cd $\leq 0.10$ and Hg $\leq 0.50$ mg/kg (BPOM Regulation No. 5/2018) (a, b) |
| CCP-2 | Deep-frying             | Biological: surviving microorganisms; Chemical: degraded oil | Oil $\geq 175$ °C for $\geq 3$ min (c)                                                                                                                                             |
| CCP-3 | Storage of packed snack | Biological: mould; Physical: damaged packs                   | RH $\leq 65\%$ , $\leq 30$ °C, sealed packs (d)                                                                                                                                    |

Source: decision tree adapted from Kosasih et al. (2025) and Codex Alimentarius Commission (2020). Notes: the limits are specifications for incoming material and for process control, not acceptance criteria for the finished snack. (a) SNI 8273:2016 and BPOM Regulation No. 13/2019. (b) BPOM Regulation No. 5/2018, applied to the raw material as a precaution. (c) Practical limit, not validated; comparable to  $180 \pm 10$  °C for 4–7 min (Ruenda et al., 2025). (d) Chosen to limit the rise in water activity, which was not measured.

CCPs were identified with a four-question decision tree (adapted from Kosasih et al., 2025; Codex Alimentarius Commission, 2020) applied to each step in turn (Table 3). A step is a CCP when Q2 is answered yes, or when Q2 is no, Q3 is yes and Q4 is no. For receipt of dried fish, Q2 was yes because rejecting non-conforming lots is the only point at which arsenic and a high plate count can be kept out of the process, and no later step removes arsenic. For deep-frying, Q2 was yes because heat is the only step designed to reduce the microbial load. Storage of the packed snack was a CCP through Q3 and Q4: leaking or damp packs allow mould growth and recontamination, and the snack is eaten without further heating. Sorting, washing, seasoning and packing were not CCPs, because the hazards there are controlled by GMP and SSOP.

Table 3. Decision-tree answers for each process step

| Process step                         | Q1  | Q2  | Q3  | Q4 | Decision             |
|--------------------------------------|-----|-----|-----|----|----------------------|
| Receipt of dried fish                | Yes | Yes | –   | –  | CCP-1                |
| Deep-frying                          | Yes | Yes | –   | –  | CCP-2                |
| Storage of packed snack              | Yes | No  | Yes | No | CCP-3                |
| Sorting, washing, seasoning, packing | Yes | No  | No  | –  | Not a CCP (GMP/SSOP) |

Q1, control measure exists? Q2, step designed to eliminate or reduce the hazard? Q3, contamination could exceed acceptable limits? Q4, later step eliminates the hazard? Source: decision tree adapted from Kosasih et al. (2025) and Codex Alimentarius Commission (2020); answers from this study.

The critical limits come from national regulations and were set as supplier specifications for incoming dried fish, which is different from the criteria used to judge the finished snack. At CCP-1, the plate count limit of  $1 \times 10^5$  CFU/g follows SNI 8273:2016 for dried salted fish and equals the lower limit (m) of BPOM Regulation No. 13 of 2019, and *Salmonella* must be absent in 25 g under the same regulation. No regulation sets metal limits for dried fish used as a raw material, so the limits of BPOM Regulation No. 5 of 2018 for fish and fishery products were adopted as a precaution, because frying does not remove metals. The finished snack was judged only against BPOM Regulation No. 5 of 2018 for metals (Table 6); its microbial quality was not tested in this study. Plate count and *Salmonella* are grouped under CCP-1 because both are biological hazards that enter with the raw material and are controlled by the same measures, approval of the supplier and rejection of non-conforming lots. They differ in what they show

and in how they are monitored. The plate count is an indicator of the overall hygiene of drying and handling and, like metals, cannot be seen at receipt, so it is verified from supplier documents and periodic laboratory tests (every six months in the plan). *Salmonella* is a specific pathogen whose limit is absence and can only be detected in the laboratory, so it should be added to the periodic laboratory submission. Sensory inspection of every delivery backs up both checks, but it detects only gross spoilage.

The frying limit of 175 °C for at least 3 min was chosen as a combination of temperature and time that a small producer can reach and check with a digital thermometer on every batch. It was not adopted from a standard and was not derived from a lethality study of this product. Two published reference points are available. A catfish-skin chip MSME in Bandar Lampung used  $180 \pm 10$  °C for 4–7 min as its critical limit, which came from its own HACCP analysis rather than from a standard (Ruenda *et al.*, 2025), and experimental fish crackers cut into slices about 2 mm thick were fried at 160, 170 and 180 °C for 10 s (Tokarczyk *et al.*, 2025). Both show that 175 °C lies within the range used for thin fish snacks, but neither measured microbial reduction, so neither validates the limit. At UD. Hamid Jaya, product thickness, batch size and core temperature were not recorded, and the reduction in microorganisms after frying was not measured. The limit is therefore a provisional operating limit, and it is considered adequate only for the thin, battered pieces of dried fish that were fried in this study. Validation would need the core temperature of the thickest pieces at the end of the minimum frying time, and plate counts and *Salmonella* tests before and after frying in several batches.

At CCP-3, the limits of RH  $\leq 65\%$  and  $\leq 30$  °C with sealed packs were set so that the packed snack, which is low in moisture (3.27%), does not take up water in the store room. The relative humidity in equilibrium with a food corresponds to its water activity, so RH  $\leq 65\%$  corresponds to a water activity of about 0.65. Most bacteria need a water activity above 0.85, but yeasts and moulds can grow at values as low as 0.61, and almost no microbial growth is expected below 0.60 (Fitri *et al.*, 2022). The RH limit is therefore a practical rather than a conservative limit: it sits slightly above the lowest water activity at which moulds have been reported to grow, and it relies on sealed packs and on the low moisture of the snack to keep the water activity of the product itself lower than that of the store room air. The temperature limit reflects the finding that storage temperature strongly affects the growth rate of *Listeria monocytogenes* in ready-to-eat fish products (Cipriani *et al.*, 2025). In the plan, RH and temperature are read daily with a hygrometer, readings are logged, pack integrity is checked before distribution, and the hygrometer is calibrated monthly. Water activity was not measured in this study because the equipment was not available, and no storage trial was carried out, so no record of RH or temperature over a storage period is reported and the limits were not tested against the actual water activity of the stored snack. This is a limitation, because mould growth is more directly related to water activity than to moisture content alone.

Table 4. HACCP plan: monitoring, corrective action and verification for each CCP

| CCP                                  | Critical limit                                                                                                                         | Monitoring                                                              | Corrective action                                                                         | Verification and records                                                                                                       |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| CCP-1<br>Receipt<br>of dried<br>fish | Plate count $\leq 1 \times 10^5$<br>CFU/g; <i>Salmonella</i><br>absent in 25 g; As, Pb,<br>Cd, Hg within BPOM<br>Regulation No. 5/2018 | Sensory inspection and<br>supplier documents at every<br>delivery       | Reject or return non-<br>conforming lots; stop<br>production; change supplier             | Monthly audit of incoming<br>material; laboratory tests<br>(plate count, metals) every<br>six months; receiving record<br>form |
| CCP-2<br>Deep-<br>frying             | Oil $\geq 175$ °C for $\geq 3$ min                                                                                                     | Digital thermometer reading<br>for every batch; frying time<br>recorded | Fry again; discard the batch<br>if temperature is not reached;<br>recalibrate thermometer | Monthly thermometer<br>calibration; periodic<br>microbial test of finished<br>product; daily temperature<br>log                |

| CCP                              | Critical limit                            | Monitoring                                                                                     | Corrective action                                                         | Verification and records                                                                         |
|----------------------------------|-------------------------------------------|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| CCP-3<br>Storage of packed snack | RH $\leq$ 65%; $\leq$ 30 °C; sealed packs | Daily RH and temperature reading with a hygrometer; pack integrity checked before distribution | Move stock to a drier room; replace damaged packs; discard mouldy product | Monthly hygrometer calibration; sensory check of stored samples; daily RH and temperature record |

Source: HACCP plan prepared in this study.

The three CCPs form a chain. CCP-1 is the only point that can keep arsenic and a high bacterial load out of the product, CCP-2 reduces the microbial load that passes CCP-1 but cannot remove metals, and CCP-3 protects the snack after the last heat step. A failure at CCP-1 therefore cannot be made up for later, which is why most of the monitoring effort is placed there. All procedures can be carried out by production staff with a digital thermometer, a hygrometer and record sheets, without laboratory equipment on site. Missing batch records were one of the major deviations found with the CPPB-IRT checklist (Table 1), so a record sheet is attached to each CCP; a written plan of this kind gives the owner a basis for accountability to inspectors and customers (Lee et al., 2023). Until the limits are validated, they should be treated as provisional operating limits and reviewed after the first six months of records and the first periodic laboratory results.

### Microbial and Chemical Hazards

The dried fish failed the aerobic plate count limit of SNI 8273:2016 (a lower-bound result of  $>2.5 \times 10^5$  CFU/g, not an exact count) but tested negative for *Salmonella* spp. (Table 5). Neither pyrethroids nor formaldehyde were detected. In the finished snack, cadmium, lead and mercury stayed below the limits of BPOM Regulation No. 5 of 2018 and tin was not detected, but total arsenic (0.697 mg/kg) was about 2.8 times the limit of 0.25 mg/kg (Table 6). This compares total arsenic with the regulatory limit and is not an assessment of inorganic arsenic exposure.

Table 5. Microbial quality of the dried cobia bought as raw material

| Parameter              | Measured value           | Limit (SNI 8273:2016; BPOM 13/2019) | Assessment  |
|------------------------|--------------------------|-------------------------------------|-------------|
| Aerobic plate count    | $>2.5 \times 10^5$ CFU/g | $1 \times 10^5$ CFU/g               | Above limit |
| <i>Salmonella</i> spp. | Not found in 25 g        | Absent in 25 g                      | Meets limit |

Source: PT Eurofins Angler Biochemlab, report AR-26-DL-017456-01. The plate count was reported as a lower bound ( $>2.5 \times 10^5$  CFU/g), not as an exact count.

Table 6. Pesticides, formaldehyde and heavy metals in the raw material and snack

| Analyte             | Measured (mg/kg)       | Limit (mg/kg)         | Assessment                          |
|---------------------|------------------------|-----------------------|-------------------------------------|
| Bifenthrin          | $<0.01$ (not detected) | None set <sup>a</sup> | Not detected                        |
| Cypermethrin        | $<0.01$ (not detected) | None set <sup>a</sup> | Not detected                        |
| Formaldehyde        | $<1$ (not detected)    | Banned <sup>b</sup>   | Not detected                        |
| Cadmium (Cd)        | 0.023                  | 0.10                  | Meets limit (23%)                   |
| Lead (Pb)           | 0.044                  | 0.20                  | Meets limit (22%)                   |
| Arsenic, total (As) | 0.697                  | 0.25                  | Exceeds limit (about 2.8 $\times$ ) |
| Mercury, total (Hg) | $<0.05$ (not detected) | 0.5                   | Meets limit                         |
| Tin (Sn)            | $<0.1$ (not detected)  | None set              | No limit set                        |

Source: PT Eurofins Angler Biochemlab, reports AR-26-DL-017456-01 and AR-26-DL-017327-01; metal limits from BPOM (2018a), which sets no tin limit for this category.. <sup>a</sup>No SNI limit exists for pesticides in fishery

products (SNI 7313:2008 covers plant produce only); values were compared with the quantification limit of 0.01 mg/kg. <sup>b</sup>Formalin is not permitted as a food additive (Permenkes, 2012).

### Nutritional Composition and Sensory Scores

Per 100 g, the snack contained 457 kcal, 39.7% protein, 20.7% fat, 28.1% carbohydrate, 3.27% water, 8.27% ash and 2.14% salt (Table 7). All four sensory attributes scored above the acceptance threshold of 7; texture was rated highest with the smallest spread, odour lowest with the widest spread, and the mean of all attributes was 8.03 (Table 8).

Table 7. Proximate composition of crispy cobia (per 100 g)

| Component    | Value    | Method                        |
|--------------|----------|-------------------------------|
| Energy       | 457 kcal | Calculated                    |
| Protein      | 39.7%    | Kjeldahl (SNI 01-2891-1992)   |
| Fat          | 20.7%    | Soxhlet (SNI 01-2891-1992)    |
| Carbohydrate | 28.1%    | Calculated by difference      |
| Water        | 3.27%    | Gravimetry (SNI 01-2891-1992) |
| Ash          | 8.27%    | Gravimetry (SNI 01-2891-1992) |
| Salt (NaCl)  | 2.14%    | Titration                     |

Source: PT Eurofins Angler Biochemlab, report AR-26-DL-017327-01.

Table 8. Hedonic scores given by eight panelists (scale 1–9)

| Sensory attribute | Score (mean $\pm$ SD) |
|-------------------|-----------------------|
| Appearance        | 7.88 $\pm$ 0.83       |
| Odour             | 7.50 $\pm$ 1.20       |
| Taste             | 8.13 $\pm$ 0.99       |
| Texture           | 8.63 $\pm$ 0.52       |
| All attributes    | 8.03 $\pm$ 0.57       |

Source: primary data.

### Community Perception

Thirty-six of the 60 people living within 500 m of the premises returned the questionnaire (participation rate 60%). Their answers gave a grand mean of 4.12 out of 5, and no item fell below 3.9 (Figure 5). Residents rated the business highest for providing social facilities (4.31) and for supporting the local economy (4.28), and lowest for its general effect on social life in the area (3.97). Nobody gave a neutral or negative answer; 75.0% of respondents placed the business in the "good" band and 25.0% in "very good" (Table 9).

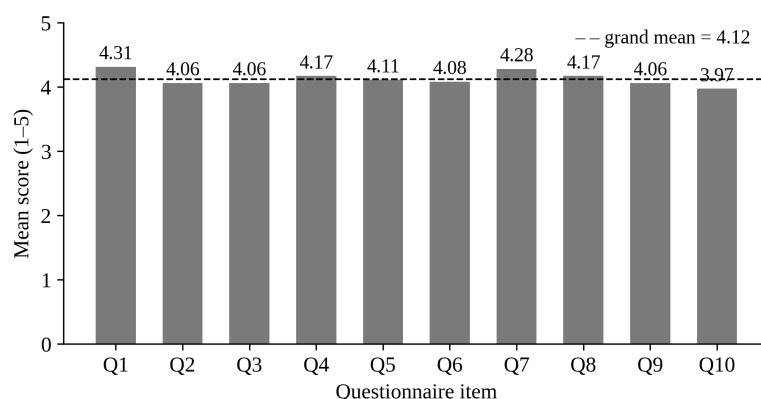


Figure 5. Mean score for each questionnaire item (n = 36); the dashed line marks the grand mean.

Table 9. Respondents grouped by total perception score (n = 36; population = 60)

| Band      | Total score | Respondents | Share (%) |
|-----------|-------------|-------------|-----------|
| Very poor | 10-18       | 0           | 0.0       |
| Poor      | 19-26       | 0           | 0.0       |
| Neutral   | 27-34       | 0           | 0.0       |
| Good      | 35-42       | 27          | 75.0      |
| Very good | 43-50       | 9           | 25.0      |

Source: SPSS frequency analysis of primary data.

## DISCUSSION

### Prerequisite Programmes as the Basis of HACCP

Level II means that practice is fairly sound but still needs internal audits and regular corrective work. Fish processors in Pulau Banyak, Aceh Singkil, showed a similar profile: they did not yet meet every basic requirement, although their products stayed within microbial limits (Hasanah *et al.*, 2023). The contrast is a cuttlefish fillet plant where GMP and SSOP were applied without lapses and combined with pest control and ongoing staff training, which kept its products hygienic and of good quality (Listyaningrum *et al.*, 2025). The building remains the weak spot at UD. Hamid Jaya, since the processing environment is a recognised source of microbial contamination in fish products (Sheng & Wang, 2021), and surfaces that are not watertight cannot be sanitised properly. Missing records are typical of small food firms; in a study spanning many countries, record-keeping improved once a food safety management system was introduced together with more training (Lee *et al.*, 2023).

### Why Raw Material Receiving Carries the Greatest Risk

The business relies wholly on what its supplier sends, and a chemical hazard such as arsenic builds up in the fish and cannot be taken out later in the process. Tuna processors reach the same conclusion and treat receiving as the main point for controlling chemical and early microbial hazards (Denden *et al.*, 2024). The plate count result supports this choice. A count of at least 2.5 times the SNI limit points to a heavy load of aerobic mesophiles, although it does not prove that a pathogen is present, because the method counts all aerobic mesophilic bacteria together. The laboratory reported the result as an inequality (above  $2.5 \times 10^5$  CFU/g), that is, as a lower bound and not an exact count, so the true count is unknown and may be considerably higher, and the exceedance can only be described as at least 2.5-fold. The conclusions drawn here are therefore limited to those that hold for any count above  $2.5 \times 10^5$  CFU/g, namely that

the SNI limit and the lower BPOM limit were exceeded. The next consignment from the supplier should be tested with dilutions extended far enough to give an exact count. The result exceeds the lower plate count limit of BPOM Regulation No. 13 of 2019 for dried fish ( $1 \times 10^5$  CFU/g), but whether it also exceeds the upper limit ( $1 \times 10^6$  CFU/g) cannot be judged because only a lower bound was reported (BPOM, 2019). For comparison, the result equals more than 5.4 log CFU/g. This is higher than the mean of open sun-dried fish from Lake Tana, Ethiopia (4.90 log CFU/g, with 23.3% of samples above the acceptable limit; Birie *et al.*, 2025), but below the highest count in salted anchovies from traditional markets in Cirebon, where 9 of 10 samples exceeded the SNI limit (up to  $8.4 \times 10^6$  CFU/g; Affandy *et al.*, 2026). Dried salted scad prepared in an enclosed solar dryer, by contrast, stayed at  $5.4\text{--}5.9 \times 10^2$  CFU/g (Sormin *et al.*, 2021). This spread suggests that the drying method and handling, not the dryness of the product alone, determine the count. The supplier's drying practice was not observed in this study, so open-air drying without control of temperature or humidity, which is common among small suppliers, remains a plausible but unconfirmed source. Frying alone cannot be relied on when the fish arrives with so many bacteria.

Frying (CCP-2) is the only step in the process hot enough to kill microorganisms, and heat treatment is one of the key controls for pathogens in fish products (Sheng & Wang, 2021). Because the plate count was measured only on the raw material, the lethality of frying for this product was not tested. Nobody reheats crispy cobia before eating it, so storage (CCP-3) is the final safeguard against mould that could grow if damp air raised the water activity of the product; dried fish with lower moisture and water activity carries fewer bacteria (Birie *et al.*, 2025). Before this study, quality was managed from the owner's experience without anything written down, a situation typical of small food businesses with limited staff and resources (Dima *et al.*, 2024). Simple checks that are recorded every time are a realistic starting point for an MSME, since record-keeping and corrective action improved after food safety management systems were introduced together with training (Lee *et al.*, 2023), and the corrective actions chosen follow the preventive logic of HACCP (Codex Alimentarius Commission, 2020; Garrido Gamarro *et al.*, 2023). Verification and documentation, the last two HACCP principles, still need the most work at UD. Hamid Jaya.

### **Chemical Hazards: Pesticides, Formaldehyde and Arsenic**

Pesticides are among the chemical contaminants commonly reported in fish (Issa-Zacharia *et al.*, 2025), and residues still turn up in national monitoring of fishery products (Kyung *et al.*, 2025). Finding no pyrethroids therefore suggests that this batch of fish had not picked up such residues, although one sample cannot show that the whole supply is free of them. The absence of formaldehyde matters just as much. Formalin may not be added to food in Indonesia (Permenkes, 2012), yet it is still found in salted fish on market stalls (Affandy *et al.*, 2026) and is a recurring problem across Asia and Africa (Kaur *et al.*, 2024). Arsenic is the result that needs follow-up. At 0.697 mg/kg, total arsenic in the snack was about 2.8 times the BPOM limit of 0.25 mg/kg, so the product does not meet the regulation on this parameter, whereas cadmium (0.023 mg/kg) and lead (0.044 mg/kg) were well below their limits and mercury and tin were not detected. The result must nevertheless be read with care. Only total arsenic was measured, and in marine fish most arsenic is arsenobetaine, an organic form regarded as non-toxic, unlike inorganic arsenic (Sadee *et al.*, 2024). In Indonesia, the estimated intake of inorganic arsenic from fishery products (0.04–0.08 µg/kg body weight/day) is only about 3% of the intake of total arsenic (1.19–2.67 µg/kg body weight/day; Dwiwitno *et al.*, 2024). The inorganic, carcinogenic fraction in this product therefore remains unknown (EFSA, 2024). Exceeding the total-arsenic limit is therefore a regulatory finding on the product as sampled. It is not an assessment of inorganic arsenic exposure or of health risk, which would need speciation and data on how much of the snack is eaten. Other dried fish give a mixed

picture, although the weight basis and methods differ between studies. Salted sun-dried fish in Thailand contained 0.004-4.533 mg/kg of total arsenic (Thanaratsotornkun *et al.*, 2026), whereas arsenic was not detected in ten dried fish species in Bangladesh, although the X-ray fluorescence method used there had a detection limit of 0.41 mg/kg, higher than the BPOM limit (Rakib *et al.*, 2021). Arsenic in dried fish thus depends strongly on species and origin. The catch location and the arsenic content of the dried fish before frying were not available here, so the source of the arsenic cannot be established. Heat does not destroy metals, and losing water concentrates them, as shown for dried fish (Sroy *et al.*, 2023); total arsenic was also higher in fried than in raw marine fish from Guangdong, China (Zhang *et al.*, 2022). Long-term monitoring in Southeast Sulawesi shows that metal levels in the same fish species can change from year to year (Saputri *et al.*, 2023), which argues for routine rather than one-off testing. Arsenic is therefore best managed at CCP-1, through supplier approval, a written arsenic specification, a certificate of analysis for each batch, and arsenic speciation in later samples.

### **Nutritional and Sensory Quality**

Protein at 39.7% is high for a fried dried-fish product. Fried ready-to-eat salted anchovy, whose 2.08-2.42% moisture is closest to this snack, contained 27.13-36.70% protein (Fahmi *et al.*, 2023), and dried salted anchovy only 31.89-33.15% (Bau *et al.*, 2021), while unbattered dried salted scad reached 59.11% (Sormin *et al.*, 2021). Moisture strongly affects these figures: on a dry basis, the snack's protein is 41.0%, almost the same as dried salted anchovy (40.8-41.1%) but lower than dried scad (71.9%). The gap with the unbattered dried fish is expected, because the batter (28.1% carbohydrate) and frying oil (20.7% fat) dilute the fish protein. The comparison is only indicative, since species and drying methods differ between studies and Kjeldahl protein is crude protein calculated from total nitrogen. Fat is picked up in the fryer, where evaporating water leaves space that oil fills (Oppong *et al.*, 2021); how much oil a piece absorbs depends on its starting moisture and the frying conditions, and pre-drying can cut it down (Lumanlan *et al.*, 2020). Most of the carbohydrate comes from the batter. With only 3.27% water, the snack leaves little free water for moulds and spoilage bacteria, much as salted fish becomes drier as salt rises (Nurfitriyani *et al.*, 2024), and dried fish with lower moisture carries fewer microbes (Birie *et al.*, 2025). The high ash probably reflects minerals in the dried fish plus salt and spices, and the salt content equals roughly 0.84 g of sodium per 100 g, so a clear serving size on the label would help consumers who watch their sodium intake. Because two businesses handle the fish, one drying and the other frying it, nutrient levels may vary between batches: drying alone raised the protein of penja fish from 17.98% to 63.80% (Kasim *et al.*, 2025). Checking each delivery at CCP-1 would therefore also protect nutritional consistency. On the sensory side, crispness in fried food comes from water boiling off and leaving a hard, porous crust, shaped by oil temperature and by the movement of water and oil during frying and cooling (Wang *et al.*, 2023), which explains the high and uniform texture scores. The wider spread for odour is consistent with the partly subjective nature of sensory judgement, one reason why instrumental methods for assessing fish quality are being developed (Madhubhashini *et al.*, 2024), and it may also be widened by differences in how each batch was dried by the supplier.

### **Social Acceptance**

Household-scale processing businesses are generally seen as contributing to jobs and community welfare (Vinatra, 2023). The pattern fits UD. Hamid Jaya: because the fish arrives dried, the premises only season, fry and pack, with no landing, washing or large-scale drying that could produce smells, waste water or noise. High scores for social facilities and neighbourly relations are consistent with this view of MSMEs as contributors to community

welfare (Vinatra, 2023). The economic benefit lies mainly in jobs for processing, packing and selling, and in traditional fish processing elsewhere in Indonesia these tasks are shared among village women and men (Apituley *et al.*, 2025). This goodwill gives the owner room to hire more local workers and to tell neighbours openly where the raw fish comes from. Two features of the design may have raised the scores. Respondents were chosen because they knew or had taken part in the business, so they may view it more favourably than residents with no contact, and some may benefit from it directly; answers given face to face may also reflect a wish to please. That no respondent gave a neutral or negative answer should therefore be read as the view of residents close to the business, not as proof that the whole neighbourhood approves.

### Limitations

Several limits should be kept in mind. The study covers a single enterprise and one sampling period, so the results cannot be generalised to other producers or seasons. The laboratory results come from one sample of the finished snack and one sample of the dried fish, so batch-to-batch variation could not be assessed. The plate count was measured only on the raw material and was reported as a lower bound, and only total arsenic was measured, without arsenic speciation. Water activity could not be measured because of limited equipment, the frying and storage limits were not validated by core-temperature or storage trials, and the efficacy of frying in reducing microorganisms was not tested. The sensory panel consisted of eight semi-trained officers evaluating one product, and the questionnaire reached 36 of 60 neighbours chosen purposively because they knew the business, so the social results describe this neighbourhood and may lean positive. Future work should test several batches and seasons, measure the plate count on the finished product and the water activity of the snack, validate the frying limit, and include inorganic arsenic.

### CONCLUSION

The CPPB-IRT checklist placed UD. Hamid Jaya at IRTP Level II, with two major deviations (building surfaces and batch records) and one minor deviation (cleaning routine). The laboratory results showed that the purchased dried fish exceeded the SNI 8273:2016 plate count limit, with a result reported only as a lower bound, and that the finished snack contained total arsenic of 0.697 mg/kg, about 2.8 times the BPOM limit of 0.25 mg/kg. Cadmium, lead and mercury were within their limits, tin was not detected, and *Salmonella* spp., pyrethroids and formaldehyde were absent. The snack was high in protein (39.7%), low in moisture (3.27%) and well liked, and neighbours who knew the business viewed it positively.

The following are interpretations and recommendations based on the HACCP analysis, not results demonstrated by the tests. Receipt of the dried fish, frying and storage of the packed snack were designated as CCPs, and receipt carries most of the risk because the fish is bought already dried. Keeping the product safe will depend on approving and checking suppliers, writing down every HACCP check, testing for arsenic, including its inorganic form, at regular intervals, and validating the frying and storage limits. These conclusions are limited by the single enterprise, the one sampling period and the small sensory and community samples.

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## REFERENCES

- Affandy, F., Rochima, E., Suryana, A. A. H., & Rostini, I. (2026). Evaluasi Keamanan Pangan Ikan Asin Bilis (*Stolephorus* sp.) di Beberapa Pasar Tradisional Kota Cirebon. *Journal of Tropical AgriFood*, 8(1), 19-28. <https://doi.org/10.35941/jtaf.8.1.2026.21960.19-28>
- Anandito, R. B. K., Purwanto, E., Praseptiangga, D., & Zaman, M. Z. (2024). Optimization of Cobia Fish (*Rachycentron canadum*) Gelatin Extraction with Response Surface Methodology. *Food Research*, 8(Suppl. 2). [https://doi.org/10.26656/fr.2017.8\(S2\).98](https://doi.org/10.26656/fr.2017.8(S2).98)
- Andhikawati, A., Junianto, J., Permana, R., & Oktavia, Y. (2021). Review: Komposisi Gizi Ikan Terhadap Kesehatan Tubuh Manusia. *Marinade*, 4(2), 76-84. <https://doi.org/10.31629/marinade.v4i02.3871>
- Apituley, Y. M. T. N., Nanlohy, H., Rieuwpassa, F., Tapotubun, A. M., & Matrutty, T. E. A. (2025). Gender Roles in Traditional Fish Processing Business in Small Islands in Maluku. *Saintek Perikanan: Indonesian Journal of Fisheries Science and Technology*, 21(4), 299-305. <https://doi.org/10.14710/ijfst.21.4.299-305>
- Bau, F. C., Une, S., & Antuli, Z. (2021). Pengaruh Lama Pengeringan Terhadap Kualitas Kimia dan Biologis Ikan Teri Asin Kering (*Stolephorus* sp.). *Jambura Journal of Food Technology*, 3(2), 94-101. <https://doi.org/10.37905/jjft.v3i2.9101>
- Benetti, D. D., Suarez, J., Camperio, J., Hoenig, R. H., Tudela, C. E., Daugherty, Z., McGuigan, C. J., Mathur, S., Anchieta, L., Buchalla, Y., Alarcón, J., Marchetti, D., Fiorentino, J., Buchanan, J., Artilles, A., & Stieglitz, J. D. (2021). A Review on Cobia, *Rachycentron canadum*, Aquaculture. *Journal of the World Aquaculture Society*, 52(3), 691-709. <https://doi.org/10.1111/jwas.12810>
- Birie, S., Mingist, M., Kibret, M., Atlog, T. Y., Geremew, H., & Getnet, B. (2025). Proximate Composition, Microbiological Quality and Safety of Raw and Open Sun-Dried Fish Products in Lake Tana, Ethiopia. *Food Science & Nutrition*, 13(1), e4671. <https://doi.org/10.1002/fsn3.4671>
- BPOM. (2012). *Peraturan Kepala Badan Pengawas Obat dan Makanan Nomor HK.03.1.23.04.12.2207 Tahun 2012 Tentang Tata Cara Pemeriksaan Sarana Produksi Pangan Industri Rumah Tangga*. Jakarta: Badan Pengawas Obat dan Makanan Republik Indonesia.
- BPOM. (2018a). *Peraturan Badan Pengawas Obat dan Makanan Nomor 5 Tahun 2018 Tentang Batas Maksimum Cemaran Logam Berat dalam Pangan Olahan*. Jakarta: Badan Pengawas Obat dan Makanan Republik Indonesia.
- BPOM. (2018b). *Peraturan Badan Pengawas Obat dan Makanan Nomor 22 Tahun 2018 Pedoman Pemberian Sertifikat Produksi Pangan Industri Rumah Tangga*. Jakarta: Badan Pengawas Obat dan Makanan Republik Indonesia.
- BSN. (1992). *SNI 01-2891-1992: Cara Uji Makanan dan Minuman*. Jakarta: Badan Standardisasi Nasional.
- BSN. (2008). *SNI 7313:2008: Batas Maksimum Residu Pestisida pada Hasil Pertanian*. Jakarta: Badan Standardisasi Nasional.

- BSN. (2015). *SNI 2346:2015: Pedoman Pengujian Sensori pada Produk Perikanan*. Jakarta: Badan Standardisasi Nasional.
- BSN. (2016). *SNI 8273:2016: Ikan Asin Kering*. Jakarta: Badan Standardisasi Nasional.
- Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive Sampling: Complex or Simple? Research Case Examples. *Journal of Research in Nursing*, 25(8), 652-661. <https://doi.org/10.1177/1744987120927206>
- Cipriani, P., Dalzini, E., Cosciani-Cunico, E., Abdul, M.-E., Monastero, P., Merigo, D., Ducoli, S., Norton, A., Losio, M.-N., & Pavoni, E. (2025). Growth Rate Determination of *Listeria monocytogenes* in Ready-To-Eat Fish Products Under Different Storage Conditions for Possible Shelf-Life Extension. *Foods*, 14(5), Article 777. <https://doi.org/10.3390/foods14050777>
- Codex Alimentarius Commission. (2020). *General Principles of Food Hygiene (CXC 1-1969, Rev. 2020)*. Rome: FAO/WHO.
- Denden, I., Njehi, M., & Krifi, B. (2024). Implementation of HACCP System in a Tuna Fish Industry. *World Journal of Advanced Research and Reviews*, 21(3), 1899-1909. <https://doi.org/10.30574/wjarr.2024.21.3.0158>
- Dima, A., Radu, E., & Dobrin, C. (2024). Exploring Key Barriers of HACCP Certification Adoption in the Meat Industry: A Decision-Making Trial and Evaluation Laboratory Approach. *Foods*, 13(9), 1303. <https://doi.org/10.3390/foods13091303>
- Dwiyitno, D., Andarwulan, N., Lioe, H. N., Imanningsih, N., Giriwono, P. E., Presiana, D., Adriany, R., Nikastri, E., Pusparini, N., Audia, I., Amaliya, N. N., & Takhwifa, F. (2024). Estimated Inorganic Arsenic from Total Arsenic in Fishery Products and its Health Risk to the Indonesian Population. *Emerging Contaminants*, 10(4), Article 100340. <https://doi.org/10.1016/j.emcon.2024.100340>
- EFSA. (2024). Update of the Risk Assessment of Inorganic Arsenic in Food. EFSA Panel on Contaminants in the Food Chain. *EFSA Journal*, 22(1), e8488. <https://doi.org/10.2903/j.efsa.2024.8488>
- Fahmi, A. S., Susanto, E., & Sumardianto, S. (2023). Karakteristik Ikan Teri Nasi (*Stolephorus* spp.) Asin Goreng Siap Makan dengan Perlakuan Perendaman dalam Air Panas Sebelum Penggorengan. *Saintek Perikanan: Indonesian Journal of Fisheries Science and Technology*, 19(1), 47-53. <https://doi.org/10.14710/ijfst.19.1.47-53>
- Febrianti, A. A., Susanto, E., Purnamayati, L., Sumardianto, S., & Suharto, S. (2023). Penggunaan Gelatin Kulit Ikan Cobia (*Rachycentron canadum*) untuk Perbaikan Karakteristik Fruit Leather Buah Naga Merah. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 26(2), 177-190. <https://doi.org/10.17844/jphpi.v26i2.43392>
- Fitri, N., Chan, S. X. Y., Che Lah, N. H., Jam, F. A., Misnan, N. M., Kamal, N., Sarian, M. N., Mohd Lazaldin, M. A., Low, C. F., Hamezah, H. S., Rohani, E. R., Mediani, A., & Abas, F. (2022). A Comprehensive Review on the Processing of Dried Fish and the Associated Chemical and Nutritional Changes. *Foods*, 11(19), Article 2938. <https://doi.org/10.3390/foods11192938>
- Garrido Gamarro, E., Svanevik, C. S., Lundebye, A. K., Sanden, M., D'Agostino, E., Kjelleve, M., Pincus, L., & Pucher, J. (2023). Challenges in the Implementation of Food Safety and Quality Assurance Systems in Small-scale fisheries. *Food Quality and Safety*, 7, fyad007. <https://doi.org/10.1093/fqsafe/fyad007>
- Hafiludin, H., Chandra, A. B., Alfisuma, M. Z., & Pratiwi, W. S. W. (2025). Peningkatan Nilai Tambah Produk Perikanan Pesisir dengan Perbaikan Kemasan dan Pemasaran. *Jurnal Pembelajaran Pemberdayaan Masyarakat (JP2M)*, 6(3), 695-711. <https://doi.org/10.33474/jp2m.v6i3.23747>

- Hapsari, Y. A., Apriyanti, P., Hermiyanto, A., & Rozi, F. (2024). Analisa Peran UMKM Terhadap Perkembangan Ekonomi di Indonesia. *Jurnal Manajemen dan Ekonomi Kreatif*, 2(4), 53-62. <https://doi.org/10.59024/jumek.v2i4.464>
- Hasanah, U., Khairi, I., Akbardiansyah, Ukhty, N., Rozi, A., & Insani, S. A. (2023). Kelayakan Dasar UMKM Pengolahan Ikan di Kecamatan Pulau Banyak, Aceh Singkil. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 26(3), 485-496. <https://doi.org/10.17844/jphpi.v26i3.46013>
- Ilhami, M., & Nisak, K. (2025). Pengaruh Penambahan Ikan Jenggelek (*Rachycentron canadum*) terhadap Karakteristik Kimia dan Organoleptik pada Produk Mie Kering. *Ekliptika*, 5(2), 43-48. <https://doi.org/10.55757/ekliptika.v5i2.568>
- Issa-Zacharia, A., Msangi, R. S., & Mboya, G. R. (2025). Revisiting Chemical and Microbiological Quality and Safety of Fish and Fish Products. *International Journal of Microbiology and Biotechnology*, 10(3), 73-90. <https://doi.org/10.11648/j.ijmb.20251003.12>
- Jespersen, L., & Wallace, C. A. (2017). Triangulation and the Importance of Establishing Valid Methods for Food Safety Culture Evaluation. *Food Research International*, 100(1), 244-253. <https://doi.org/10.1016/j.foodres.2017.07.009>
- Kasim, A., Astuti, I., & Darmawan, D. (2025). Chemical Composition of Fresh and Dried Penja Fish (*Sicyopterus pugnans*). *Nekton: Jurnal Perikanan dan Kelautan*, 5(2), 88-96. <https://doi.org/10.47767/nekton.v5i2.1049>
- Kaur, G., Tripathy, S., Rout, S., Mishra, G., Panda, B. K., & Srivastav, P. P. (2024). Formalin Adulteration in Fish: A State-of-the-Art Review on its Prevalence, Detection Advancements, and Affordable Device Innovations. *Trends in Food Science & Technology*, 153, 104708. <https://doi.org/10.1016/j.tifs.2024.104708>
- Kim, D.-Y., Jeon, H., & Shin, H.-S. (2023). Risk Assessment and Determination of Arsenic and Heavy Metals in Fishery Products in Korea. *Foods*, 12(20), 3750. <https://doi.org/10.3390/foods12203750>
- Kosasih, W., Florencia, G., Andres, & Salomon, L. L. (2025). Implementation of Hazard Analysis Critical Control Point (HACCP) in a Shrimp Crackers Production SME. *Jurnal Rekayasa Sistem Industri*, 14(2), 185-201. <https://doi.org/10.26593/jrsi.v14i2.8517.185-201>
- Kyung, K. S., Kim, D. J., Oh, E. B., Moon, J. H., Choi, J. W., Kim, T. H., Lee, S. H., Park, J. Y., & Kwon, C. H. (2025). Nationwide Monitoring and Risk Assessment of Pesticide Residues in Fishery Products. *Toxics*, 13(9), 778. <https://doi.org/10.3390/toxics13090778>
- Lee, J. C., Neonaki, M., Alexopoulos, A., & Varzakas, T. (2023). Case Studies of Small-Medium Food Enterprises Around the World: Major Constraints and Benefits from the Implementation of Food Safety Management Systems. *Foods*, 12(17), 3218. <https://doi.org/10.3390/foods12173218>
- Listyaningrum, N. P., Hamida, J., & Rumiati, S. (2025). Analysis of the Implementation of Good Manufacturing Practice (GMP) and Sanitation Standard Operating Procedure (SSOP) in the Processing of Cuttlefish (*Sepia* sp.) Fillets. *Journal of Tropical Food and Agroindustrial Technology*, 6(2), 39-46.
- Lumanlan, J. C., Fernando, W. M. A. D. B., & Jayasena, V. (2020). Mechanisms of Oil Uptake During Deep Frying and Applications of Predrying and Hydrocolloids in Reducing Fat Content of Chips. *International Journal of Food Science & Technology*, 55(4), 1661–1670. <https://doi.org/10.1111/ijfs.14435>
- Madhubhashini, M. N., Liyanage, C. P., Alahakoon, A. U., & Liyanage, R. P. (2024). Current Applications and Future Trends of Artificial Senses in Fish Freshness Determination: A

- Review. *Journal of Food Science*, 89(1), 35-50. <https://doi.org/10.1111/1750-3841.16865>
- Marwiyah, S., & Lailatul Fitria, N. J. (2023). Implementation of the Blue Economy Policy in Probolinggo City for the Development of the Creative Economy of Processed Fisheries and Marines. *Jurnal Borneo Administrator*, 19(1), 51-68. <https://doi.org/10.24258/jba.v19i1.1148>
- Nurfitriyani, A., Triyastuti, M. S., Shitophyta, L. M., Wahidi, B. R., & Mukhaimin, I. (2024). Perhitungan Kadar Air, Rendemen dan Uji Organoleptik pada Ikan Asin. *Media Teknologi Hasil Perikanan*, 12(1), 45-55. <https://doi.org/10.35800/mthp.12.1.2024.53300>
- Oppong, D., Panpipat, W., Cheong, L. Z., & Chaijan, M. (2021). Comparative Effect of Frying and Baking on Chemical, Physical, and Microbiological Characteristics of Frozen Fish Nuggets. *Foods*, 10(12), 3158. <https://doi.org/10.3390/foods10123158>
- Permen KP. (2019). *Peraturan Menteri Kelautan dan Perikanan Nomor 17/PERMEN-KP/2019 tentang Persyaratan dan Tata Cara Penerbitan Sertifikat Kelayakan Pengolahan*. Jakarta: Kementerian Kelautan dan Perikanan Republik Indonesia.
- Permenkes. (2012). *Peraturan Menteri Kesehatan Nomor 033 Tahun 2012 tentang Bahan Tambahan Pangan*. Jakarta: Kementerian Kesehatan Republik Indonesia.
- Purnamasari, H. B., Fitriyani, E., & Farida, L. (2023). Proses Pengolahan Fillet Cobia (*Rachycentron canadum*) Skinless Beku di PT. Mahkota Samudera Jaya, Muara Baru-Jakarta Utara. *Buletin Jalanidhitah Sarva Jivitam*, 5(1), 63-72. <https://doi.org/10.15578/bjsj.v5i1.10785>
- Radu, E., Dima, A., Dobrota, E. M., Badea, A. M., Madsen, D. Ø., Dobrin, C., & Stanciu, S. (2023). Global Trends and Research Hotspots on HACCP and Modern Quality Management Systems in the Food Industry. *Heliyon*, 9(7), e18232. <https://doi.org/10.1016/j.heliyon.2023.e18232>
- Rakib, M. R. J., Jolly, Y. N., Enyoh, C. E., Khandaker, M. U., Hossain, M. B., Akther, S., Alsubaie, A., Almalki, A. S. A., & Bradley, D. A. (2021). Levels and Health Risk Assessment of Heavy Metals in Dried Fish Consumed in Bangladesh. *Scientific Reports*, 11, Article 14642. <https://doi.org/10.1038/s41598-021-93989-w>
- Ruenda, O., Marvie, I., Lianti, L., Sihombing, M., Irbadh, M., Sinaga, F., & Silaban, M. (2025). Evaluasi CPPB-IRT dan HACCP pada UMKM Olahan Limbah Kulit Ikan Patin. *Jurnal Ilmu Pangan dan Hasil Pertanian*, 9(1), 42-53. <https://doi.org/10.26877/jiphp.v9i1.23700>
- Sadee, B. A., Galali, Y., & Zebari, S. M. S. (2024). Recent Developments in Speciation and Determination of Arsenic in Marine Organisms Using Different Analytical Techniques: A Review. *RSC Advances*, 14(30), 21563-21589. <https://doi.org/10.1039/d4ra03000a>
- Saputri, M., Yusnaini, Y., Sara, L., Widowati, I., Guyot, T., Fichet, D., & Radenac, G. (2023). Multi-Year Monitoring of the Toxicological Risk of Heavy Metals Related to Fish Consumption by the Population of the Kendari Region (Southeast Sulawesi, Indonesia). *Toxics*, 11(7), 592. <https://doi.org/10.3390/toxics11070592>
- Setyohadi, D., Pamungkas, R. S., Purwanto, H., Sunardi, Sulkhany, E., Syawli, A., Rahman, M. A., & Kadhafi, M. (2024). Enhancing Fisheries Management and Sustainability: A Stowage Factor Analysis of Fish Species at Mayangan Port, Indonesia. *International Journal of Design & Nature and Ecodynamics*, 19(6), 1939-1949. <https://doi.org/10.18280/ijdne.190610>
- Sheng, L., & Wang, L. (2021). The Microbial Safety of Fish and Fish Products: Recent Advances in Understanding its Significance, Contamination Sources, and Control Strategies. *Comprehensive Reviews in Food Science and Food Safety*, 20(1), 738-786. <https://doi.org/10.1111/1541-4337.12671>

- Sormin, R. B. D., Lokollo, E., Gaspersz, F. F., & Tahalea, V. F. J. (2021). Proksimat dan Total Bakteri Ikan Layang (*Decapterus* sp.) Asin Kering Hasil Pengeringan Menggunakan Pengering Surya Tertutup. *INASUA: Jurnal Teknologi Hasil Perikanan*, 1(1), 29-39.
- Sroy, S., Avallone, S., Servent, A., In, S., & Arnaud, E. (2023). Does Drying Preserve the Nutritional Quality of Small Freshwater Fish without Excessive Concentrations of Heavy Metals? *Current Research in Food Science*, 6, 100489. <https://doi.org/10.1016/j.crfs.2023.100489>
- Thanaratsotornkun, P., Sridonpai, P., Boonyingsathit, K., Tanaviyutpakdee, P., Laitip, N., Ornthai, N., Yafa, C., & Judprasong, K. (2026). Risk Assessment of Heavy Metals Exposure from Consumption of Salted-Sun-Dried Fish. *Food Chemistry Advances*, 11, Article 101283. <https://doi.org/10.1016/j.focha.2026.101283>
- Tokarczyk, G., Bienkiewicz, G., Biernacka, P., Przybylska, S., Sawicki, W., & Tabaszewska, M. (2025). Effect of Frying Temperature on Lipid Binding, Fatty Acid Composition, and Nutritional Quality of Fish Crackers Prepared from Carp (*Cyprinus carpio* L.) and Tapioca Starch (*Manihot esculentus*). *Molecules*, 30(5), Article 1139. <https://doi.org/10.3390/molecules30051139>
- U.S. Food and Drug Administration. (2026). *BAM Chapter 3: Aerobic Plate Count* (G. Zhang, M. Ferguson, & R. J. Blodgett). Bacteriological Analytical Manual. <https://www.fda.gov/food/laboratory-methods-food/bam-chapter-3-aerobic-plate-count>
- Van Durme, J., Spagnoli, P., Duy, L. N. D., Nhi, D. T. L., & Jacksens, L. (2024). Maturity of Food Safety Management Systems in the Vietnamese Seafood Processing Industry. *Journal of Food Protection*, 87(4), 100240.
- Vanany, I., Wangsa, I. D., Savitri, N. A., Putera, R. R., Cholili, M., Wibawa, B. M., Atmaja, L., & Tseng, M. L. (2024). Social-Economic and Environment Impacts for a Fish Reverse Supply Chain: A Mixed Integer Linear Optimization Approach. *Cleaner Logistics and Supply Chain*, 13, 100189.
- Vinatra, S. (2023). Peran Usaha Mikro, Kecil, dan Menengah (UMKM) dalam Kesejahteraan Perekonomian Negara dan Masyarakat. *Jurnal Akuntan Publik*, 1(3), 1-8. <https://doi.org/10.59581/jap-widyakarya.v1i3.832>
- Wang, X., McClements, D. J., Xu, Z., Meng, M., Qiu, C., Long, J., Jin, Z., & Chen, L. (2023). Recent Advances in the Optimization of the Sensory Attributes of Fried Foods: Appearance, Flavor, and Texture. *Trends in Food Science & Technology*, 138, 297-309. <https://doi.org/10.1016/j.tifs.2023.06.012>
- Yulyana, A., Hastuti, A. A. M. B., Rohman, A., Setiawan, B., Khasanah, F., & Irnawati. (2023). Heavy Metal Levels in Fish Products in Indonesia: A Survey. *Food Research*, 7(2), 74-84. [https://doi.org/10.26656/fr.2017.7\(2\).727](https://doi.org/10.26656/fr.2017.7(2).727)
- Zhang, L., Cao, P., Chen, Z., Mao, W., Huang, R., Zhou, P., Wang, P., & Bao, H. (2022). Study of Cooking Coefficient of Five Toxic Metals in Marine Fish in China. *Chinese Journal of Food Hygiene*, 34(5), 896-901.