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Improving the safety of *pindang*, a traditional fish product from Indonesia: case study from Palabuhanratu, Sukabumi District, West Java Province, Indonesia

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Abstract

Pindang is a popular traditional fish product in Indonesia that has been produced for decades. Scombroid fish such as tuna, mackerel, and scad, which have a naturally high level of histidine, are commonly used to make *pindang*. Hence, improper handling and processing can lead to the accumulation of histamine, potentially causing health issues. Due to uncertainty or limited availability of fresh fish, many *pindang* producers use frozen fish as an alternative raw material. Reports implicate *pindang* as a major causative agent of HFP outbreaks in Indonesia. However, detailed investigation on how histamine is formed during *pindang* processing needs to be updated based on current processing conditions. This study investigated the existing practices of *pindang* production in Palabuhanratu, Sukabumi District, West Java Province, Indonesia; evaluated potential critical control points (CCPs) of histamine production; and identified strategies to improve the safety of *pindang*. Fresh Skipjack tuna (*Katsuwonus pelamis*) and frozen Eastern Little tuna (*Euthynnus* sp.) were used as raw materials for *pindang* processing. Results showed that pindang made from fresh fish generally had lower histamine levels compared to those made from frozen fish. Improper handling, especially abusive temperatures and time delays during fish thawing, was identified as the main causes of histamine formation during *pindang* processing. Therefore, to reduce the risk of histamine formation, a temperature-controlled circulated thawing system could be used. This finding can help *pindang* producers improve the safety of their products and ensure compliance with national and international food safety standards.

Keywords Traditional processed fish, Circulated thawing system, CCPs, Intervention strategies

Introduction

Indonesia is a major global fish producer, processing 6.85 million tonnes in 2019 of which 53% is traditionally processed, followed by frozen (20%) and surimi (14%) [1, 2]. Traditional processing uses simple methods passed between generations in home or micro- and medium-scale industries, and produces the following products: dried fish, dried-salted fish, salted-boiled fish, smoked fish, and fermented fish [3]. From 2014 to 2019, the production volume of processed fish increased 21%, including traditionally processed products [4]. Salting/drying is the most popular method, representing 72%

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of all traditionally processed fish in 2019, followed by salted-boiling (16%) and smoking (11%) methods [1].

Pindang or salted-boiled fish, a popular traditionally processed fish product, is typically made from Scombroid fish such as tuna, mackerel, and scad, which known for their high level of histidine in the muscle tissue. With the increasing scarcity of fresh fish, frozen fish is now commonly used for *pindang* production. An additional step of thawing may lead to the increased risk of histamine formation, if not perform properly. Reports implicate *pindang* as a major causative agent of HFP outbreaks in Indonesia [5–9]. However, detailed investigation on how histamine is formed during *pindang* processing needs to be updated based on current processing conditions.

The history of salted-boiled fish (pindang)

Salted-boiled fish, locally named *pindang*, has been produced in Indonesia for more than 50 years, preserving fish with salt and heat [10]. Brined and salted *pindang* are common processing methods [11], classified as standard methods by the Indonesian National Standard (Standar Nasional Indonesia-SNI) (SNI 2717.3:2009, SNI 2717:2017) [12, 13]. Brined *pindang* involves soaking fish in brine and then boiling for 30–60 min (Fig. 1); while salted *pindang* involves adding salt to the fish surface before boiling in water for 1–4 h, followed by low heat for one additional hour (Fig. 2). Similarly, prepared fish products are found in other Southeast Asian countries, such as *sinaing na tulingan* in the Philippines and *pla thu nung* in Thailand [14, 15].

Since the 1980s, *pindang* has been a preferred substitution for salted-dried fish [11]. The combination of high salt concentration and heat treatment produces a firm textured product, with a desirable flavour, lower salt content, and longer shelf-life compared to fresh fish [11, 15]. In addition, only 0.7–3.9% salt remains in the final product, compared to 12–20% for salted-dried fish [16–18]. Unlike dried fish, *pindang* processing is simpler and does not depend on variable weather conditions for drying [11].

Indonesian *pindang* processors are distributed across the country (Fig. 3), with total numbers of more than 10,000 in 2019; of these, approximately 5000 were located in West Java [19, 20]. The remaining processors are located in various regions of Java, such as Central Java, East Java, Banten, Jakarta, and Yogyakarta. Fewer processors are found in West Nusa Tenggara, Sulawesi, Bali, and Sumatera [21]. The largest processing centres are in Palabuhanratu—Sukabumi District (West Java Province) and Juwana (Central Java Province) [3].

Regional variations in *pindang* preparation and flavour result from several factors, such as the choice of

Fig. 1 Standard brined *pindang* processing method according to Indonesian National Standard (SNI 2717.3:2009, SNI 2717:2017): **a** fish preparation; **b** fish soaking in boiled brine; and **c** final cooked brined *pindang*

Fig. 2 Standard salted *pindang* processing method according to Indonesian National Standard (SNI 2717.3:2009, SNI 2717:2017): **a** fish preparation; **b** adding salt to the fish surface; **c** fish boiling; and **d** final cooked salted *pindang*

raw material, salt concentration, boiling time, and packaging material. These variations are driven by distinct practices and taste preferences in societies throughout the country. As a result, these different approaches yield unique sensory qualities in the end product, affecting its organoleptic appearance and shelf-life [15]. *Pindang* is also considered a ready-to-eat product, thus enabling subsequent culinary processing and personalised presentations that display distinctive characteristic of each region.

The significance of the economic and societal contributions of *pindang*, together with the increasing product demand from cities distant to processing centres, led the Indonesian government to elevate *pindang* processing to an industrial level through Ministerial Regulation PER.27/MEN/2012, regarding general guidelines for marine and fisheries industrialisation.

In the 1980s, family and neighbourhood-based *pindang* industries in Palabuhanratu (Sukabumi District, West Java Province) were established, utilising basic and traditional processing facilities and techniques passed between generations. Since a decade ago, fish processors were forced to change the raw material from fresh to frozen tuna, due to limited availability of fresh tuna from local catchments. Frozen tuna constitutes 15–20% of total raw material used for the production of *pindang* [22].

Apart from tuna, *pindang* can be made from a wide range of raw materials, including freshwater fish species such as milkfish, barb, tilapia, and carp, as well as marine fish species such as scad, mackerel, milkfish, pomfret, herring, and sardines [23]. Amongst these fish species, Scombroid fish including tuna, mackerel, and scad require specific attention during handling and

Fig. 3 Geographic distribution of *pindang* processors in Indonesia (2019). Most of the processors were located in Java Island, including West Java, Central Java, East Java, Banten, Jakarta, and Yogyakarta provinces. Fewer processors were found in West Nusa Tenggara, Sulawesi, Bali, and Sumatera

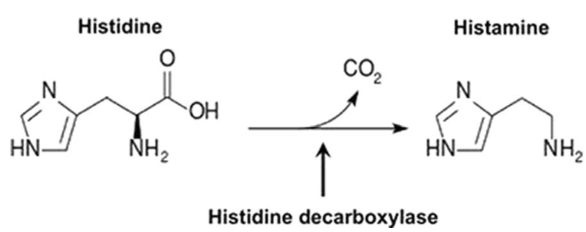

Fig. 4 Histamine biosynthesis through the histidine decarboxylation pathway. The conversion of histidine into histamine is mediated by histidine decarboxylase (*hdc*) enzyme, which is produced by histamine-producing bacteria (HPB)

processing, as they are more susceptible to histamine contamination due to naturally high levels of histidine [24–32]. Mediated by histidine decarboxylase (*hdc*) enzyme, free histidine in fish is metabolised by histamine-producing bacteria (HPB) to histamine (Fig. 4) [33, 34], either by *hdc* produced endogenously in fish muscle and/or exogenously by bacteria (*e.g.* Enterobacteriaceae) on fish [33, 35–38]. The formation and accumulation of histamine may lead to histamine fish poisoning (HFP), a foodborne intoxication due to consumption of fish or other foods containing toxic levels of histamine [35, 39–41].

Strategies to reduce or prevent histamine formation, which are applicable in *pindang* processing facilities, should also be identified. Therefore, this study observes current processing practices for *pindang* in Palabuhanratu and describes critical control points (CCPs) in processing that can potentially increase safety of *pindang*.

Materials and methods

Field observation and fish sample collection

Fish samples were collected from traditional fish processors in Palabuhanratu, Sukabumi District, West Java Province, Indonesia. Five *pindang* processors were selected and observed during processing. Fish temperature during processing was recorded using a four-channel thermocouple data logger (DTM-319 TECPEL, Taiwan). Three replicates of raw and cooked fish were collected for microbiological and histamine analysis.

Microbiological analysis

The viable counts of fish samples were analysed following method by Rachmawati et al. [42]. Five grams of fish flesh was homogenised in 45 ml of phosphate buffer saline (PBS) (pH 7.4). The homogenate was then serially diluted in PBS and spread-plated on tryptone soya broth (Oxoid, CM0129, UK) supplemented with 1.5% agar and 2%

NaCl. Incubation was performed aerobically at 30 °C for 24 h. Total viable counts were expressed as log CFU/g.

Histamine analysis

Histamine extraction from fish sample

Histamine was extracted following the methods of Sirochi et al. [43], with some modification. Fish flesh was blended and then 5 g extracted with 15 ml 15% trichloroacetic acid (TCA) (Sigma, USA). The homogenate was centrifuged at 2500×*g* for 10 min, and approximately 10 ml of the supernatant transferred to a new tube. After that, 100 µl of 10 µg/ml histamine.2HCl (α, α, β, β-D4, 98%) (Novachem, AU) was added to the supernatant, as internal control for histamine. Sample pH was adjusted by adding 200 µl of 28% NH_4OH (Sigma, USA).

Sample clean-up was performed using a SPE STRATA X cartridge 33 µm polymeric reverse-phase (30 mg/3 ml) (Phenomenex, AU). Prior to sample loading, the cartridge was conditioned twice with 2 ml methanol followed by 2 ml Milli-Q water. Two ml of sample was loaded into the cartridge and then rinsed with 2 ml of $MeOH/H_2O$ (5/95 *v/v*). The cartridge was dried under vacuum to remove excess water, and the analyte was eluted twice with 2 ml methanol/acetic acid (99/1 *v/v*), and then dried with nitrogen gas. Analyte was re-dissolved in 2 ml Milli-Q water prior to chromatographic analysis.

Chromatographic analysis

Chromatographic analysis was performed following a method of Rachmawati et al. [42]. The mobile phase consisted of two solvents: 0.1% (v/v) formic acid in water (solvent A) and acetonitrile (solvent B). The UPLC programme was 100% A to 60% A: 40% B at 3.0 min, which was held for 0.5 min. This was followed by immediate re-equilibration to starting conditions for 3 min. The flow rate was 0.20 ml/min. Sample injection volume was 10 µL. Approximate retention time for histamine was 2.9 min.

Fishbone analysis and CCP determination for histamine formation during pindang processing

Fishbone analysis is a valuable cause-and-effect diagram used to methodically examine issues and possible problematic factors in a food production system [44–47]. We employed this approach to investigate the causes of histamine formation in each step of *pindang* processing and identify the factors that contributed to the problem.

To determine the critical control points (CCPs) in *pindang* processing, we evaluated whether any measures could be implemented during processing to prevent, reduce, or eliminate the histamine formation risk to acceptable levels [48, 49]. We also utilised a decision tree and literature search to identify the CCPs. Control and preventive measures were identified based on the current processing conditions of *pindang* in Sukabumi District, West Java, Indonesia.

Results

Field observations

We studied two different raw materials used in the production of *pindang*. Two processors utilised Skipjack tuna (*Katsuwonus pelamis*) that were caught locally, while three other processors used frozen Eastern Little tuna (*Euthynnus* sp.) purchased from suppliers. Fresh skipjack, designated *pindang* type 1, were caught in local waters using a seine net on “payang” vessels that leave fishing ports between 3 and 6 am and return between 4 and 8 pm [50–52]. Frozen Little tuna were designated as *pindang* type 2.

Figure 5 depicts processing flowcharts for both *pindang* types. The average weight of individual Skipjack tuna was 3–4 kg, while the Eastern Little tuna weighed 300–400 g. The main difference between the two processing types was that *pindang* type 2 was thawed. In addition, fish for *pindang* type 1 were wrapped with paper after cooking, while fish used in type 2 were wrapped with paper prior to cooking.

For *pindang* type 1, the raw Skipjack was maintained at 5–7 °C before processing, washed, arranged, and salted within 30 min, and then cooked immediately. Before cooking, the fish temperature was 17 °C. In contrast, for *pindang* type 2, the temperature of frozen tuna was approximately − 5 °C. The fish were thawed in 60–90 min, in open air, without water replacement. During thawing, the fish temperature increased from − 5 to 13–20 °C.

To prevent direct contact between the fish and container, wooden wicker was layered between fish and water added to the bottom of containers. The fish were then arranged in layers, and salt was added between and on top of each layer, with 50–60 g of salt applied per kg fish (i.e. 5–6%). The topmost layer of fish was covered with thick plastic or paper. Fish were cooked by steaming for approximately 3–4 h. The cooked fish was cooled at room temperature (25–28 °C) and distributed within 1–2 d.

Microbiological count and histamine content

For both types of *pindang*, the total viable count (TVC) of raw fish was 3.0–4.5 log CFU/g. For type 2, raw samples were thawed fish. TVC of cooked fish was ≤ 2 log CFU/g, except for processor 2 where TVC ranged from 4.1 to 5.1 log CFU/g (Table 1). Histamine levels of *pindang* type 1 were 10–100 times lower than type 2. For the latter, increasing levels of histamine were observed from raw to cooked fish for processors 3 and 4. For processor

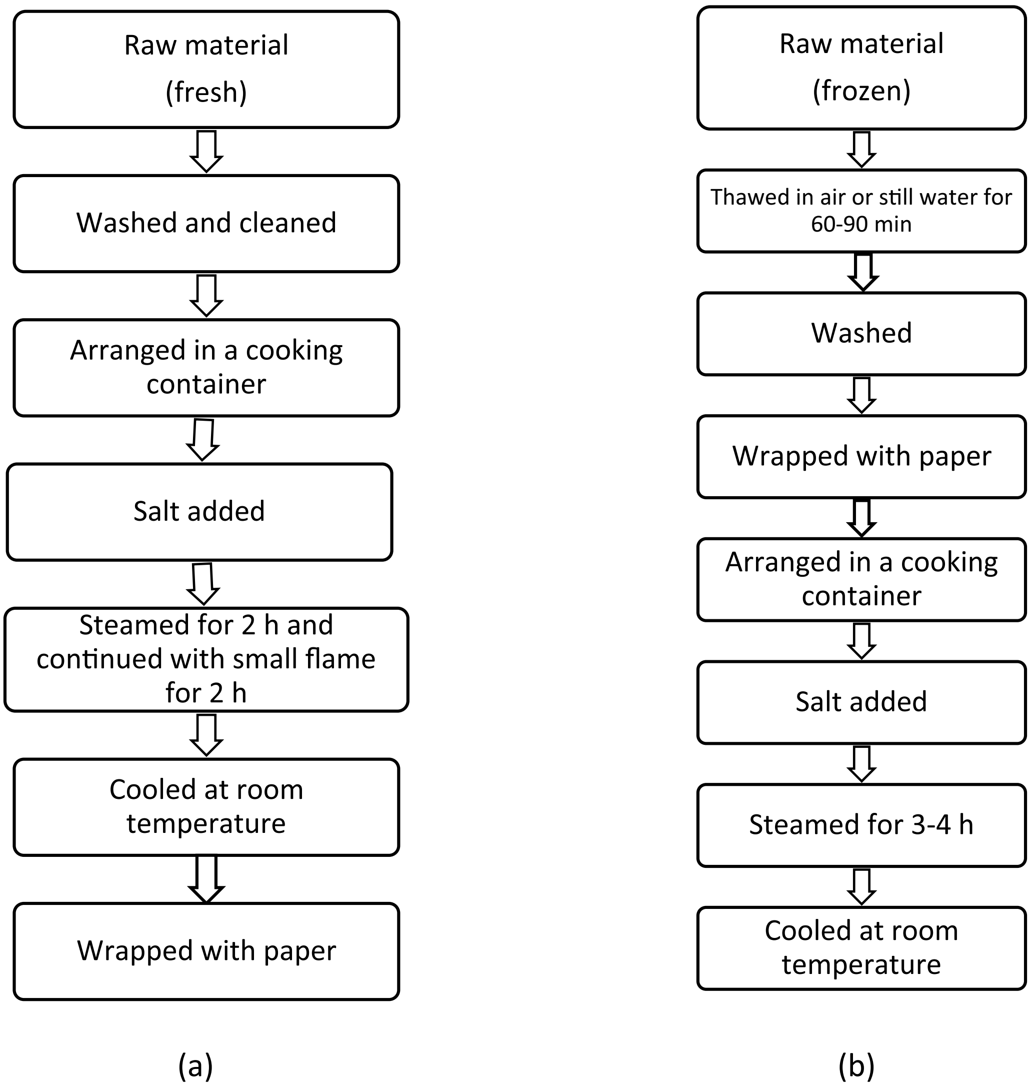

Fig. 5 Processing variations of *pindang* in Palabuhanratu: **a** *pindang* type 1 using fresh skipjack and **b** *pindang* type 2 using frozen little tuna as raw material. The final products were distributed within 1–2 days

Table 1 Average total viable counts and histamine concentration for raw and cooked fish

Fish processors	Processing type	TVC (log CFU/g)*		Histamine level (mg/kg)	
		Raw fish	Cooked fish	Raw fish	Cooked fish
Processor 1	Type 1	3.7 ± 0.4	1.6 ± 0.8	1.4 ± 0.6	3.7 ± 2.9
Processor 2	Type 1	3.7 ± 0.5	4.6 ± 0.5	0.8 ± 0.1	21.9 ± 22.8
Processor 3	Type 2	3.7 ± 0.3	1.3 ± 0.3	88.0 ± 76.7	258.3 ± 157.8
Processor 4	Type 2	3.6 ± 0.8	1.7 ± 0.5	11.9 ± 8.2	190.0 ± 69.3
Processor 5	Type 2	3.8 ± 0.5	2.0 ± 0	321.7 ± 229.8	20.3 ± 7.4

* Detection limit is 1 log CFU/g

5, the histamine was lower in cooked compared to raw fish.

Causes of histamine formation and identification of CCPs during the processing of *pindang*

Raw and cooked *pindang* from processing type 1 had low levels of histamine (< 50 mg/kg), whereas processing type 2 generally had higher levels of histamine. Some raw fish from these processors had histamine levels of more than 100 mg/kg. Generally, histamine levels increased after cooking, except for fish from processor 5. Based on these observations, processing of *pindang* type 2 was selected for fishbone analysis to determine causes of histamine formation during processing (Fig. 6).

The histamine levels in the final product depend on the initial levels in the raw materials and the activity of histamine-producing bacteria (HPB) during processing. Four main sources of HPB and histamine during *pindang* processing were identified: raw materials, preparation, cooking, and post-process handling (Fig. 6). The preparation steps included thawing, washing, wrapping with paper, arranging in a cooking container, and salting. Inadequate cooling at each step was identified as the main factor that could promote the growth of HPB.

To identify critical control points (CCPs) in *pindang* type 2 processing, a decision tree recommended by FAO/WHO [33] was used. Four questions were asked and six CCPs identified: raw materials, thawing, washing, salting, cooking, and post-process handling (Table 2). Control and preventive measures for each CCP are presented in Table 3.

Discussion

The *pindang* processing steps used in Palabuhanratu classify the final product as salted *pindang* (SNI 2717.3:2009). All raw fish, whether fresh and frozen, were tested in this study and had a TVC lower than 5.0×10^5 CFU/g, which meets the requirement set by the Indonesian Standardisation Body for fresh fish (SNI 2729–2013, SNI 2717.1: 2009). Although TVC is not a quantitative indicator of the hygienic and quality for frozen fish, it is still useful as a qualitative measure [53]. The cooked *pindang* samples from four out of five processors had very low TVC values (< 2 log CFU/ml), with some samples showing no bacterial growth. These results suggest that post-cooking contamination was absent in most of the *pindang* processing investigated. However, higher TVC values were observed from the cooked *pindang* of processor 2, which could

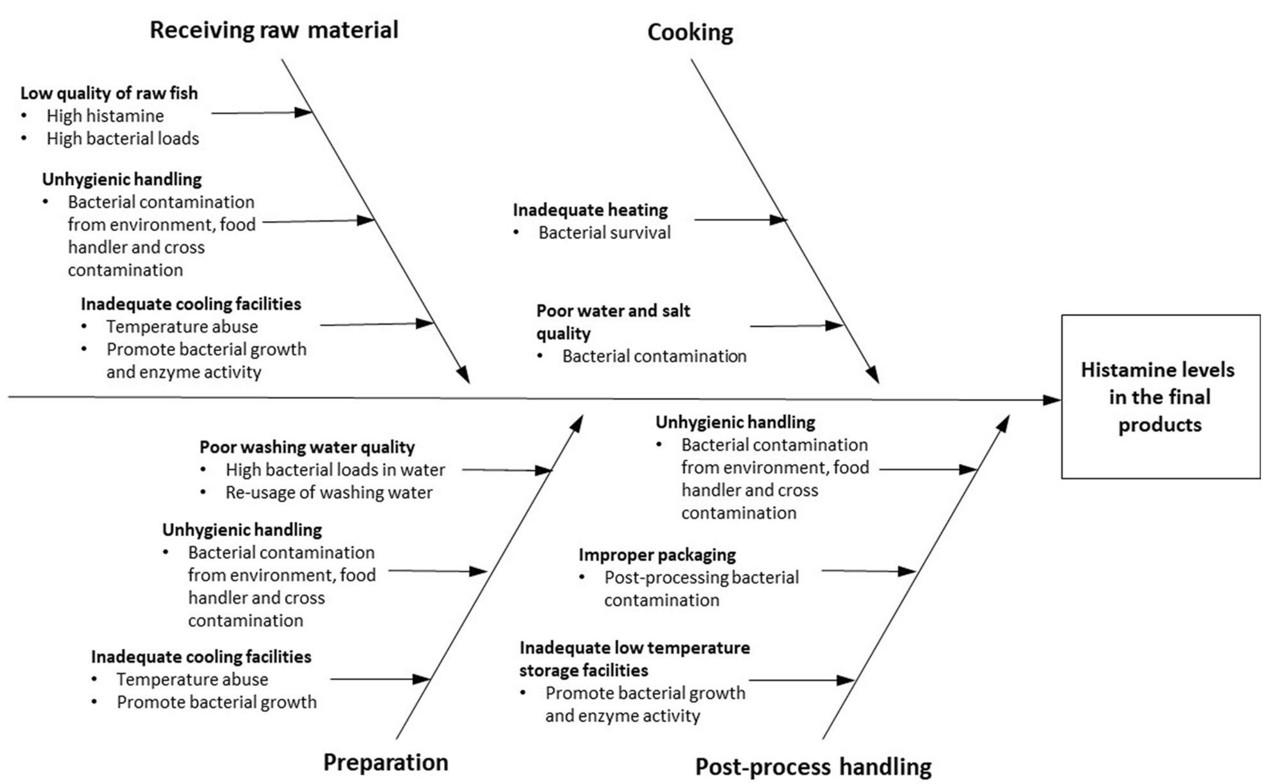

Fig. 6 Identified critical control points in *pindang* type 2 processing, as sources of bacterial contamination and histamine accumulation. The stages include receiving of raw materials, fish preparation, cooking, and post-process handling

Table 2 Decision tree questions to identify CCPs of *pindang* processing

Process	Q1: Do preventive control exist?	Q2: Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?	Q3: Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels?	Q4: Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to an acceptable level?	Is this step a CCP?
Receiving raw material	Y	N	Y	N	Y
Thawing in air or still water for 60–90 min	Y	N	Y	N	Y
Washing	Y	N	Y	N	Y
Wrapping with paper	Y	N	N		N
Arranging fish in the cooking container	Y	N	N		N
Adding salt	Y	Y			Y
Steaming for 3–4 h	Y	Y			Y
Chilling at room temperature	Y	N	Y	N	Y

Table 3 CCPs and control measures to prevent histamine formation in *pindang* type 2

Processing step	Hazards	Preventive or control measures	CCPs
Receiving raw materials	Presence of histamine in raw fish	Use good quality of fresh fish (as recommended in SNI 2729–2013)	CCP 1
	Presence of HPB in raw fish	Keep fish temperature low (< 5 °C) as recommended in SNI 2729–2013 and SNI 2717.3–2009	
Thawing	Growth of HPB as fish exposed to high temperature for long time	Keep fish temperature low (< 5 °C) during thawing	CCP 2
	Formation of histamine by HPB	If using uncirculated water, thaw fish for less than 30 min and replace water periodically	
	Bacterial contamination from water used to thaw the fish and between fish	If using circulated water, keep water temperature at < 20 °C	
Washing	Bacterial contamination from water used to wash fish	Keep fish temperature at maximum 5 °C as recommended in SNI 2717.3–2009	CCP 3
	Bacterial contamination (e.g. HPB) from fish viscera	Clean/gut fish properly and avoid cross contamination	
	Growth of HPB due to time delay	Perform this step immediately and avoid time delay	
Salting	Survival of halotolerant HPB	Add salt (10–20% w/w) as recommended in SNI 2717.3:2009	CCP 4
Cooking	Survival of HPB due to inadequate heating	Heat/boil fish thoroughly	CCP 5
	Presence of preformed histamine due to its heat stability*		
Post-process handling	Contamination of bacteria from environment due to improper packaging	Use proper packaging	CCP 6
		Cool and store fish in a clean place	

* Preformed histamine cannot be eliminated by cooking/heating

be due to unhygienic handling when wrapping fish with paper before storage.

The accumulation of histamine in fish depends on both the presence of free histidine and activity of histidine decarboxylase-producing bacteria (HPB) that convert histidine to histamine using the *hdc* enzyme [33, 54, 55]. Therefore, fish with high levels of free histidine in their muscle are more likely to accumulate histamine than other types of fish. For instance, Skipjack tuna has been found to have histidine levels of 1200–1340 mg/100 g, while Little tuna has histidine levels of 1090 mg/100 g [56, 57]. It is recommended to immediately cool these fish after harvest, particularly for fish caught in tropical countries with warm temperature and high humidity, to prevent bacterial growth and histamine formation [23, 58]. When fish have been exposed to temperatures greater than 83 °F (28.3 °C), the US FDA recommends immediate chilling on ice, refrigerated seawater, ice slurry, or brine (no more than 6 h after fish death) at 40 °F (4.4 °C), to prevent rapid formation of the *hdc* enzyme and subsequent histamine production [58].

In our study, when fresh Skipjack tuna was used as raw material for *pindang* type 1, the histamine concentrations of raw and cooked fish were very low, and no sample exceeded 100 mg/kg of histamine. Since the thawing step is not required, the fish could be processed directly, thereby avoiding time delay and abusive temperatures. Similarly, another study conducted on *pindang* from Skipjack tuna in Palabuhanratu also reported low levels (ranging from 2.03 to 26.89 mg/kg) of histamine in both the raw and cooked products [59].

However, the use of frozen Eastern Little tuna as the raw material for *pindang* type 2 resulted in some samples of both raw and cooked fish having histamine levels exceeding 100 mg/kg. The frozen fish was purchased from a local supplier, and there was no information available on how the fish was handled prior to purchase. It is possible that the fish came from different fishing vessels, which could have contributed to variations in fish quality, including histamine levels. Thawing the frozen fish during *pindang* processing could be the most critical step in histamine formation, as this process was carried out under uncontrolled temperatures. The frozen fish was initially thawed in open air, and then, the thawing continued using water in a bucket without recirculation.

To ensure the safety and quality of the fish during thawing, it is recommended to thaw in still or moving air, while maintaining the temperature at or below 18 °C [60]. If thawing in water, it is important to use clean, circulated water with the temperature controlled at or below 20 °C [60]. Unfortunately, meeting these requirements can be challenging for the *pindang* processors located in rural areas with limited access to cooling facilities [61] and clean water supplies. Thawing fish in uncontrolled conditions also creates a risk for bacterial cross contamination between the fish and the environment. This step, which only took 60–90 min, provides favourable conditions for bacterial growth and might allow HPB to produce high levels of histamine. For example, based on the growth and histamine prediction model of *M. morganii* in the Food Spoilage and Safety Predictor (FSSP) software (www.fssp.dtu.dk), an initial amount of HPB at 3.5×10^3 CFU/g could multiply by 4.3×10^3 CFU/ml after 90 min of fish thawing at 30 °C.

Although 6% salt (60 g/kg of fish) was added shortly before cooking, it may not be sufficient to prevent the growth of halotolerant histamine-producing bacteria (HPB) during the preparation phase. Studies have suggested that *Vibrio*, *Staphylococcus* and *Pseudomonas*, which are halotolerant HPB, may contribute to histamine formation in fish products. These bacterial genera can grow and produce histamine at salt concentration of up to 10–15% NaCl in histidine broth or 12% NaCl in sardine [62–65]. To prevent histamine formation in salted fish products, a combination of salt and refrigeration is more effective [33, 66]. Refrigerated brined anchovies (14% salt w/v) showed very low histamine levels (< 0.5 mg/kg), while at room temperature, histamine levels were > 500 mg/kg, inversely related to the salt concentration [67]. This approach might be suitable for cooked *pindang*. High salt concentration in the final product could prevent the growth of bacteria that might come from post-processing contamination. Storage at a refrigerated temperature could improve the product's shelf-life. However, it should be noted that *pindang* processors in rural areas may face challenges in implementing these measures due to limited access to refrigeration facilities and clean water supplies.

HACCP is an effective method to improve food product safety and quality by improving the food production process [48, 49]. This study focused on the likelihood of histamine formation during *pindang* processing; therefore, the presence of HPB and histamine at different stages of processing were identified as critical control points (CCPs). The previous studies have identified three CCPs in Indonesian *pindang* processing, *i.e.* materials receiving, cooking, and post-processing handling [68, 69]. The identification of these CCPs was not only based on the presence of HPB and histamine but also other hazards such as pathogenic bacteria, formaldehyde, heavy metals, and foreign materials. In our study, three additional CCPs were found for processing *pindang* type 2, *i.e.* thawing, washing, and salting. The use of fresh fish is recommended as the first preventive measure, as the levels of histamine in raw fish will determine the levels in the final products. Since histamine is heat stable, preformed histamine cannot be eliminated by heating in subsequent processing steps [21, 58]. Additionally, it is crucial to maintain appropriate fish temperature during processing to control the growth and activity of HPB.

Defining CCPs during *pindang* processing is crucial for improving the practices of processors. To prevent histamine formation and accumulation in the final product, processors must implement the suggested control and preventive measures of CCPs, even if their facilities do not yet have a fully established HACCP system. However, before applying HACCP procedures, it is essential to have several prerequisite programmes in place, such as Good Manufacturing Practice for foods, Good Hygienic Practices (GHP), Codex Codes of Practice, and other food safety requirements determined by competent authorities. In Indonesia, hygiene and sanitation practices of *pindang* processing are regulated by SNI 2717.2017, which covers not only tuna-based *pindang* but also *pindang* made from other non-Scombroid fish. However, this regulation does not explicitly mention HPB and histamine as hazards in the *pindang* processing. Moreover, it aims to control hazards based on general processing steps such as receiving raw materials, gutting, washing, salting, cooking, cooling, packaging, and storing. Since the use of frozen fish is not common amongst non-Scombroid *pindang*, the thawing step is not included as a critical step in this regulation.

Conclusion

The study conducted in Palabuhanratu, Sukabumi District, West Java Province, Indonesia, examined two types of *pindang* processing. The study found that the levels of histamine in *pindang* were influenced by the quality of raw materials and processing practices. To ensure the safety of *pindang* produced by traditional fish processors in Indonesia, it is recommended that fresh fish be used as raw material. However, if frozen fish is used, care must be taken during the preparation step, including maintaining low fish temperature during thawing and avoiding time delays. The identified CCPs and their respective control and preventive measures can serve as a valuable guideline for processors to improve their processing practices.

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Author contributions
NR designed the research, collected data from field work, performed laboratory analysis, analysed and interpreted data, and wrote the manuscript. RT assisted field work data collection and data interpretation. TR provided suggestion for the experimental design and input for the manuscript. SP provided suggestion for the experimental design and input for the manuscript. MT provided suggestion for the experimental design and input and constructive review of the manuscript.

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Availability of data and materials
All data and materials have been presented in the paper.

Declarations

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Not applicable.

Consent for publication
The authors approve the publication of this manuscript.

Competing interests
The authors declare that they have no competing interest.

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