Histamine Fish Poisoning (HFP) in Indonesia: Current status and challenges.

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Abstract. Histamine fish poisoning (HFP) is one of many global food safety issues experienced by fish industries in both developed and developing countries, in which temperature abuse and mishandling during processing, storage, and distribution were identified as the main sources of histamine formation and accumulation in the products. In Indonesia, official reports on HFP are limited, however, mass media documented HFP cases and outbreaks which occurred every year, from different regions of Indonesia. The Scombroid fish, including Bullet and Frigate Tuna locally named as *Tongkol* (*Auxis rochei, A. thazard*), was reported as the main food vehicle causing the majority of HFP cases. The maximum allowable level of histamine for fresh and processed fish marketed in Indonesia is 100 mg/kg, except for fresh tuna for sashimi (50 mg/kg), based on Indonesian National Standard (SNI). The results from official control and monitoring programs by Indonesian's government as well as published studies reported the presence of elevated levels of histamine in fish sold at domestic markets, hence implementing the cold-chain system during post-harvest stages is still a challenge. Evaluation of the current national requirement for histamine testing for fish products also important, to ensure product safety prior to consumption.

Keywords: *tongkol; domestic market; national standard; temperature; fish products safety*

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1. Introduction

Histamine is one of many global food safety issues affecting both developed and developing countries. In Indonesia, the consumption of tuna (*tuna*), mackerel or bullet tuna (*tongkol*) and skipjack (*cakalang*) which domestically named as TTC, was commonly associated with histamine fish poisoning (HFP) or previously named as Scombroid fish poisoning [1]. Fish with naturally high level of histidine, which generally belong to family Scombridae, including tuna and albacore (*Thunnus*), skipjack (*Katsuwonus*), mackerel (*Scomber*), and bonitos [2] were likely contained a high level of histamine that may lead to HFP cases. Histamine formation and accumulation in fish products occur due to a combination of temperature abuse and mishandling of Scombroid fish during processing, storage and distribution [2-6]. Hence, as far as misconduct on the handling and processing practices of Scombroid fish still found in fish industries, the risk of HFP still present globally in both developed and developing countries.

Histamine in fish is produced through decarboxylation of histidine by bacteria which naturally present in fish or as a result of contamination. This catabolism process is catalysed by histidine decarboxylase (*hdc*) enzyme [7]. Enterobacteriaceae species such as *Morganella morganii*, *Raoultella planticola, R. ornithinolytica, Hafnia alvei, Klebsiella pneumonia, Citrobacter freundii, Enterobacter aerogenes* and *Proteus vulgaris* are known as prolific histamine producing bacteria and are usually implicated to HFP cases [8-12].

2. Current status of HFP cases/outbreaks in Indonesia

Official reports on HFP cases/outbreaks in Indonesia, providing information such as the implicated food (fish product), the histamine level, the presence of histamine producing bacteria, the reported symptoms, and the number of patients, are still limited. The Indonesian Ministry of Health together with the National Agency of Drug and Food Control are the competent authorities responsible for investigation and countermeasures of outbreaks related to infectious disease and food poisoning at local and national levels (Ministry of Health Regulation 2/2013).

A systematic review on published and unpublished investigation reports and studies about foodborne outbreaks in Indonesia reported 1.176 foodborne outbreaks occurred during 2005 – 2015 [13]. As defined in the Indonesian Health Ministry Regulation No. 949/MENKES/SK/VII/2004, a case with patients/affected people between 10 to more than 300 people is categorized as an outbreak. However, only 175 of these reports have completely identified the food vehicles and the poisoning agents causing the outbreaks. Pathogenic bacteria such as *Eschericia coli*, *Bacillus cereus* and *Staphylococcus* sp. were amongst the most common causes of poisoning, with more than 15% of the total cases were due to contamination of these pathogens. While chemically, histamine was reported as the major cause of the reported foodborne poisoning outbreaks (6.7%). To date, the most available information on the reported HFP cases is mainly obtained from the newspaper. In the last five years, more than 800 people suffered from HFP, with 25% of the patients were hospitalized (Table 1).

Table 1. HFP cases in Indonesia reported from local newspapers during 2015 – 2020.

Number of affected consumers (patients)	Location	Suspected fish vehicle	References
34 hospitalized	Malang (East Java)	Frigate/bullet tuna	[14]
10 hospitalized	Cilacap (Central Java)	Frigate/bullet tuna	[15]
200 (86 hospitalized)	Aceh (Special Region of Aceh)	Frigate/bullet tuna	[16]
37 hospitalized	Tenggarong (East Kalimantan)	Frigate/bullet tuna	[17]
14 (5 hospitalized)	Jambi	Frigate/bullet tuna	[18]
>100 received treatment in local health facilities	Kolaka (Southeast Sulawesi)	Skipjack tuna	[19]
300 received treatment in local health facilities	Jember (East Java)	Frigate/bullet tuna	[20]
50 (3 hospitalized)	Pasaman (West Sumatera)	Frigate/bullet tuna	[21]
53 (21 hospitalized)	Pemalang (Central Java)	Frigate/bullet tuna	[22, 23]
19 received treatment in local health facilities	Batang (Central Java)	Frigate/bullet tuna	[24]

Note: Frigate/bullet tuna (Local name: Tongkol); Skipjack tuna (Local name: Cakalang)

In all reported cases, symptoms such as nausea, vomiting, dizziness, skin rash, breath difficulties (dyspnea), and diarrhoea appeared shortly up to 2 hours after fish consumption. These symptoms corresponded with published reports on HFP clinical symptoms (Table 2). Most people also recovered within 24 hours, thus cases involved one to few persons are usually remain unreported [6, 25]. HFP symptoms are known to be mild and self-limited, thus patients usually self-medicated. These factors contribute to the low reports of HFP cases in Indonesia.

Table 2. Published clinical symptoms of HFP.

Clinical symptoms of HFP	Reference
A peppery taste, numbness of the tongue, headache, flushing and sweating, dizziness, nausea, diarrhoea, and dyspnea	[26]
Skin rashes, mouth tingling, vomiting, dyspnea (difficulty breathing)	[27]
Diarrhoea, rash, nausea, vomiting, fever, abdominal pain	[25]
Nausea, vomiting, headache, skin rashes	[14]

Frigate/bullet tuna (*Auxis* sp., *Euthynnus affinis*) was identified as the most common source of poisoning from these reports, which can be related to the availability of this product in domestic market all year round. In addition, the average national price of frigate/bullet tuna at producer level was relatively cheaper (IDR 23,838 -24,666/kg), compare to tuna (IDR 31,647 – 32,834) and skipjack (IDR 24,607 – 26,082) [28]. Tuna and tuna-like fish (TTC) are amongst the most popular and economically important capture commodities in Indonesia. From 7.2 million tonnes of total Indonesian capture fisheries production in 2018, the production of TTC composed 306; 492 and 488 thousand tonnes, respectively [29].

Amongst other seafood, TTC were the most commonly consumed fish by Indonesian's household. According to the survey of household consumption on animal-based sources in Indonesia in 2014, TTC were consumed by 24% of all respondents which was higher than other types of seafood. In addition, the calculated TTC consumption for urban and rural consumer in 2014 were 3.4 and 4.1 (National);14.5 and 17.2 (Household) kg/cap/year,

respectively [30]. In general, the preference of Indonesian's consumer at rural area to allocate their consumption expenditure to buy seafood product (including TTC) caused by its budget priority for animal-based protein source [31]. Seafood product are cheap and accessible for consumer at rural area (especially in coastal area). Hence, the seafood consumption is higher for consumer at rural than urban area.

However, in domestic market, these commodities are often distributed with minimum or no cooling system, providing suitable environment for microbial growth, including histamine producing bacteria, and trigger histamine formation/accumulation. Histamine is a heat-stable protein which cannot destroyed by common cooking practices such as boiling, steaming, heating or freezing [1, 32], therefore its formation should be prevented prior to further processing and consumption by applying proper cold chain system.

3. Regulation regarding histamine limit in fish products in Indonesia

The National Standardization Body of Indonesia has published 92 national standards (Standar Nasional Indonesia-SNI) regarding the minimum quality and safety requirements for fish products (Table 3), including frozen, dried, boiled, fermented, fresh and cold, canned, and live fish as well as surimi-based product. These standards aimed to improve product competitiveness, to maintain fair trade as well as to provide consumer protection.

For fresh fish (SNI 2729:2013), the maximum allowable level of histamine is 100 mg/kg; and histamine testing is required for fish belong to family *Scombridae, Clupeidae, Pomatomidae,* and *Coryphaenidae* [33]. This level is similar to the level set by Canadian authority for canned, fresh and frozen Scombroid fish including tuna, mackerel and mahi-mahi [34]. Australia set higher maximum limit, i.e. 200 mg/kg of histamine as a natural toxin in fish and fish product [35]. The European Commission (EC) orders a three class sampling for fish species which naturally have high level of histamine (Reg. EC 2073/2005) where amongst nine sets of samples, no more than two samples may exceed 100 mg/kg histamine ('m'), and no sample may exceed 200 mg/kg histamine ('M') [36].

Table 3. Maximum level of histamine in different fish products as required by the SNI.

SNI number	Type of product	Histamine concentration (mg/kg)
SNI 2729:2013	Fresh fish	100
SNI 2693:2014	Fresh tuna for sashimi	50
SNI 7530:2018	Fresh tuna loin	100
SNI 2696:2013	Frozen fish fillet	100
SNI 4110:2014	Frozen fish	100
SNI 7968:2014	Frozen cooked tuna loin	100
SNI 4104:2015	Frozen tuna loin	100
SNI 8271:2016	Frozen fish steak	100
SNI3 7263:2018	Frozen marlin loin	100
SNI 2725:2013	Hot-smoked fish	100
SNI 8269:2016	Rendang tuna	100
SNI 2691:2017	Katsuobushi	100
SNI 8645:2018	Fish jerky	100
SNI 2717:2017	Salted-boiled fish	100
SNI 8222:2016	Canned sardine and mackerel	100
SNI 8223:2016	Canned tuna	100
SNI 8377:2017	Fish sauce	40 mg/100 g
SNI 7266:2017	Fish ball	100

4. Evaluation of histamine sampling monitoring plan and national standard on histamine testing

The Indonesian Fish Quarantine and Inspection Agency (FQIA) is the competent authority to monitor the quality and safety of fish landed in fishing ports or fish landing areas as well as fish sold in the markets in Indonesia. More than 3,000 fish samples were collected within the period of 2013 – 2018, which consisted of fresh and processed fish (Table 4). More than 50% of the total samples were fish which naturally have high histidine content. However, only 23.8% of these families (385 samples) were tested for histamine content including tuna and tuna-like fish (local names: tongkol, cakalang, deho, madidihang), scad, mackerel (local names: salem, gindara, kembung), sardines, trevallies, mahi-mahi, and marlin.

During the period of 2013-2018, no fresh fish tested were exceeded the allowable level of histamine (100 mg/kg) as required by National Standard of Indonesia SNI 2729:2013, however samples contained more than 50 mg/100 were still found (Table 4). For processed fish, the highest level of histamine detected during this period was 151,42 mg/kg from salted-boiled tuna in 2014. However, since 2015 no processed fish were tested for histamine, which may lead to underreporting data. Although the monitoring results showed that no fresh fish samples tested exceed 100 mg/kg, the low percentage of sample tested for histamine might causes underestimation of the real figure of histamine contamination in fish marketed domestically. Also, samples with histamine more than 50 mg/kg might pose significant risk to consumer if these samples were not handled properly following the good handling practices (GHP). To enable more valid assessment on the histamine level in fish sold in the

domestic markets, it is suggested to perform an evaluation on the fish sampling plan and to update the targeted fish which represent more high-risk groups/fish.

Table 4. The number of fish with high histidine content collected and tested for histamine during monitoring and surveillance program by the Indonesian FQIA*

Year collected	Fresh fish			Processed fish	
	Sample collected	Sample tested for histamine	Samples >50 mg/kg histamine	Sample collected	Sample tested for histamine
2013	52	19	Samples contained 65.5 and 71.5 mg/kg histamine	15	7
2014	45	24	None	25	11
2015	102	54	Samples contained 66.1; 70; 72.7; 73.3; 84.2; 85.2 and 98.8 mg/kg	0	0
2016	31	12	None	0	0
2017	770	101	Samples contained 52.2; 63.7; 70.1; 82.6; 86.9 and 92.7 mg/kg	9	0
2018	567	157	79.9 mg/kg	0	0
Total	**1567**	**367**		**49**	**18**

*Data provided by the Indonesian FQIA

Within sampling monitoring plan, the type of fish collected should adequately represent the "high-risk" fish, i.e., fish with naturally high histidine content or fish implicated to HFP cases/outbreaks. The majority of samples tested for histamine content reported in Table 4 belong to family *Scombridae* (79%), followed by *Carangidae* (11.17%), *Clupeidae* (4.16%) and small proportion of *Coryphaenidae* and *Gempylidae*. As mentioned earlier, SNI 2729:2013 required histamine testing for fresh fish from family *Scombridae, Clupeidae, Pomatomidae,* and *Coryphaenidae* [33].

To provide detail information on "high-risk" fish which can be used to evaluate the SNI reference list, literature search on fish implicated to HFP cases worldwide between 2000 – 2020 (Table 5) as well as reported cases in the US and EU were done (Table 6-7). Data on histamine-related foodborne outbreaks in the US during 2000 – 2017 was collected from the US CDC web-based National Outbreak Reporting System (NORS) (https://wwwn.cdc.gov/norsdashboard/), while reports on food with risk of histamine contamination which are distributed in the EU markets during 2000 - 2020 was obtained from the EU Rapid Alert System for Food and Feed (RASFF) portal (https://webgate.ec.europa.eu/rasff-window/portal/). The majority of fish from family Scombridae, such as tuna (Yellowfin, Bigeye, Skipjack) were reported to have elevated histidine content (exceeded the recommended level) and/or associated to HFP cases/outbreaks.

Table 5. Reported HFP cases (2000 - 2020) and histamine levels of the associated fish.

Fish name	**Histamine level (mg/kg)**	**References**
Billfish (*Makaira niglicans*)	2,570	[37]
Billfish (*Xiphias gladius*)	1,570 – 2,695	
Escolar (*Lepidocybium flavobrunneum*)		
Cooked, marinated, smoked	400-7,300	[26, 38, 39]
Fish cube (*Tetrapturus angustirostris*)	523	[40]
Herring (semi dried-whole)	2,800 - 4,800	[41]
Marlin (*Makaira nigricans*)		
Filleted	435-478	[42]
Fried striped marlin	620, 896	[43]
Mackerel (*Scomberomorus*)		
Canned	612-1,539	[44]
Fried Japanese Spanish mackerel (*Scomberomorus niphonius*)	3,318	[45]
Raw Japanese Spanish mackerel (*Scomberomorus niphonius*)	1,906	
Mackerel (saba)	1,266 - 2,423	[41]
Milkfish (*Chanos chanos*)	616 - 2,350	[46, 47]
Mahi-mahi (*Coryphaena hippurus*)	113-377; 2,000	[48-50]
Saury paste (*Cololabis* sp.)	320	[51]
Swordfish (*Xiphias gladius*)		
Filleted, fried, cooked	280-7,600	[39, 52, 53]
Frozen	6,700	[53]
Sardine		
Canned, dried	144.8 - 1,700	[10, 54]
Dumpling	958	[41]
Tuna		
Cold-smoked	914-4,550	[39]
Fresh, raw	35; 96-1,738	[39, 55]
Processed or prepared products (burger, canned, dumpling, fermented, fried, mayonaise, patties. ready to heat packed, salad, sandwich)	3,860 - 4,710, 6,432; 86-1,608; 446.2; 350; 1,824; 1,000	[27, 39, 49, 56-61]
Yellowfin tuna (*Thunnus albacares*)	470 - 4,900	[62-64]
Raw	1,720	[65]
Vacuum packed	7,100 - 9,100	[66]
Steak	290	[67]
Saute	3,100	[63]
Cooked	3,720	[65]

Table 6. Outbreaks in the US due to histamine contamination in fish during 2000 – 2017.

Fish name	Number of reports
Ahi	6
Blue marlin	3
Escolar	9
Mahi-mahi	8
Marlin	1
Salmon	1
Tuna	9
Unspecified	1
Wahoo	1
Yellowfin tuna	2

Note: identified outbreaks setting were prison/jail, private home/residence, restaurant (dine-in, take away), grocery store.

Table 7. RASFF notifications of food consignments (suspected and confirmed) with potential risk to cause HFP during 2000 – 2020.

Fish name	Product type	Histamine level (mg/kg)
Anchovies (*Engraulis encrasicolus*)	Fillet, in oil	290 – 4,200
Atlantic pomfret (*Brama brama*)	Chilled	
Butterfish/Escolar (*L. flavobrunneum*)	Fillet	208 – 1,000
Marlin	Fillet, loin	400 - 690
Sardines	Canned fillet in oil, chilled	220.3 – 1,323
Albacore (*Thunnus alalunga*)	Frozen whole	3,110 – 3,698
Atlantic Bluefin Tuna (*Thunnus thynnus*)	Fresh	1,000 – 3,603
Bigeye tuna (*Thunnus obesus*)	Vacuum-packed loin	565
Tuna	Canned, chilled, defrosted, fresh, frozen, raw, thawed, vacuum packed	5 - 10,000
Yellowfin tuna (*T. albacares*)	Chilled (fillet, loin, smoked), defrosted, fresh, frozen, marinated, thawed, vacuum packed	1 - 5,100
Yellowtail amberjack (*Seriola lalandi*)	Fresh	1,000

Based on data in Table 5-7, the following suggestions can be made to evaluate the groups of fish which currently required histamine testing as defined by SNI.

1. Published data/reports/cases listed families such as *Scombridae, Clupeidae* and *Coryphaenidae* as group of HFP implicated fish and/or fish with high level of histamine. Therefore, SNI recommendation to test these families was appropriate, but family *Pomatomidae* should no longer be included in the SNI, since no HFP reports/cases were associated with this family.

2. Families such as *Carangidae, Xiphiidae*, and *Gempylidae* were reported as fish associated with HFP cases and/or found to contain high level of histamine, therefore these families should be included in the list of fish family to be analysed for histamine content in the SNI recommendation.
3. Apart from the above-mentioned families, other families including *Dussumeridae*, *Engraulidae*, *Bromidae*, and *Istiophoridae* were also reported as group of HFP-associated fish and/or fish with high level of histamine. However, these families were not presence in Indonesian water, therefore were not recommended to be included in the list of fish family to be analysed for histamine content in the SNI recommendation., especially when local raw material is used during fish processing.

5. Future directions

Although the maximum allowable level of histamine in fish as regulated by the Indonesian government is below the toxic level (200 mg/kg) suggested by the FAO/WHO [5], conditions such as tropical environment and potential contamination during handling and processing could rapidly elevate the level of histamine in fish sold in Indonesian market. Studies suggested that the formation of histamine in fish product correlates with the growth of histamine producing bacteria (HPB), where toxic concentrations (>200 mg/kg) were observed during middle or exponential phase of bacterial growth [68, 69].

At the end of fish distribution chain in domestic market in Indonesia, fish were marketed to fish processors or food service providers and sold directly for household consumption. In 2017, 48.57% (8.4 million tonnes) of total domestic fish consumption was accounted from the household, followed by processing industries (36.74%) and food service providers such as hotels and restaurants [70]. Following this trend, controlling fish temperature at consumer's hand also plays an important role to keep the safety and quality of fish. Fish for direct consumption in the household were generally purchased from traditional or modern markets, in which controlling the cold-chain system could be a challenge by retailers or consumers. Thus, consumer education on how to safely handle fish, especially Scombroid fish, become critical. This effort should be supported by collaboration between government and private sectors to provide adequate information (i.e., education and extension), tools and infrastructures such as ice making machine for traditional fish seller in traditional market. Apart from that, the current maximum allowable level of histamine in fresh fish for direct consumption should be reviewed, to provide the highest protection for consumer.

Whilst the recommended level of histamine in fish is still applicable for fish intended as raw material in the fish processing facilities or food service providers such as restaurant or caterer, fish in this category is usually purchased directly from fish landing place or wholesales, where the cold-chain system is better managed as part of the seller good handling practices (GHP) required by the food authorities.

This review includes primary data from routine monitoring of histamine in fish products in Indonesia and secondary information from the scientific literature on HFP report worldwide, thus provides reliable science-based information to be used by the competent authority to review the present regulations related to histamine in fish. However, more recent data on histamine in fish are still needed. To improve the current status of HFP cases in Indonesia, a comprehensive and real-time platform to report HFP cases that is accessible for everyone needs to be developed by Indonesian Government (i.e. Ministry of Health, Indonesian FDA, Local Authorities). In addition, consumer awareness and their involvement to prevent HFP cases should be further investigated.

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References

1. Rachmawati N. Assessing the risk of histamine from the Indonesian salted-boiled fish (*pindang*) [Doctoral Dissertation]. Hobart, Tasmania: University of Tasmania; (2019).
2. Taylor SL. Histamine food poisoning - Toxicology and clinical aspects. CRC Crit Rev Toxicol. **17,** 2:91-128 (1986)
3. Taylor SL, Stratton JE, Nordlee JA. Histamine poisoning (Scombroid fish poisoning) - an allergy-like intoxication. J Toxicol Clin Toxicol. **27**, 4-5:225-40 (1989)
4. Baylis CL. Enterobacteriaceae. In: Blackburn CdW, editor. Food Spoilage Microorganisms. p. 654-6 (Woodhead Publishing Limited, Cambridge, 2006)
5. Food and Agriculture Organization of the United Nations, World Health Organization. Public health risks of histamine and other biogenic amines from fish and fishery products. (FAO and WHO, Rome, 2012).
6. Hungerford JM. Scombroid poisoning: A review. Toxicon. **56,** 2:231-43 (2010)
7. Tortorella V, Masciari P, Pezzi M, Mola A, Tiburzi SP, Zinzi MC, et al. Histamine poisoning from ingestion of fish or scombroid syndrome. Case Reports in Emergency Medicine. **2014**, 482531(2014)
8. Björnsdóttir-Butler K, Bolton GE, Jaykus L-A, McClellan-Green PD, Green DP. Development of molecular-based methods for determination of high histamine producing bacteria in fish. Int J Food Microbiol. **139**, 3:161-7 (2010)
9. Emborg J, Dalgaard P. Formation of histamine and biogenic amines in cold-smoked tuna: An investigation of psychrotolerant bacteria from samples implicated in cases of histamine fish poisoning. J Food Prot. **69**, 4:897-906 (2006)
10. Kanki M, Yoda T, Ishibashi M, Tsukamoto T. *Photobacterium phosphoreum* caused a histamine fish poisoning incident. Int J Food Microbiol. **92**,1:79-87 (2004)
11. Lehane L, Olley J. Histamine fish poisoning revisited. Int J Food Microbiol. **58,** 1–2:1-37 (2000)
12. Visciano P, Schirone M, Tofalo R, Suzzi G. Biogenic amines in raw and processed seafood. Front Microbiol. **3**,188:1-10 (2012)
13. Arisanti RR, Indriani C, Wilopo SA. Kontribusi agen dan faktor penyebab kejadian luar biasa keracunan pangan di Indonesia: kajian sistematis. [*Contribution of agents and factors causing foodborne outbreak in Indonesia: a systematic review*]. **34**, 3:8 (2018)
14. Ainun Y. 34 Kepala desa keracunan makanan saat diklat [*34 head of villages experience food poisoning during training in Malang*] Malang: Kompas Cyber Media; http://regional.kompas.com/read/2015/04/23/10475371/34.Kepala.Desa.Keracunan.Makanan.Saat.Diklat. (2015)
15. Susanto H. Usai santap ikan tongkol di hajatan, puluhan warga Cilacap keracunan [*Dozens of Cilacap citizens had poisoning after consuming bullet tuna in a celebration*] https://www.inews.id/daerah/jateng/usai-santap-ikan-tongkol-di-hajatan-puluhan-warga-cilacap-keracunan. (2018)
16. Umar R. 200 Santri dilarikan ke rumah sakit, diduga keracunan ikan tongkol [*200 Students were hospitalized, suspected for fish poisoning*] Aceh: Kompas;

https://regional.kompas.com/read/2018/08/01/13474581/200-santri-dilarikan-ke-rumah-sakit-diduga-keracunan-ikan-tongkol. (2018)
17. 17 Desmawangga C. Diduga Keracunan Akibat Makan Ikan Tongkol, Puluhan Siswa SMA 3 Unggulan Tenggarong Dilarikan ke RS [*Allegedly poisoned due to consumption of bullet tuna, dozens of students from SMA 3 Unggulan Tenggarong were taken to hospital*] https://kaltim.tribunnews.com/2018/08/09/diduga-keracunan-akibat-makan-ikan-tongkol-puluhan-siswa-sma-3-unggulan-tenggarong-dilarikan-ke-rs. (2018)
18. Almunanda F. Belasan atlet panjat tebing anak di Jambi keracunan tongkol [*Dozens of rock climbing athletes from Jambi had fish poisoning*] https://news.detik.com/berita/d-4254449/belasan-atlet-panjat-tebing-anak-di-jambi-keracunan-tongkol. (2018)
19. Okyl M. Diduga Keracunan Makanan, Ratusan Santri di Kolaka Dilarikan ke Puskesmas [*Allegedly food poisonied, hundreds of students in Kolaka were taken to public health center*] https://penasultra.com/diduga-keracunan-makanan-ratusan-santri-di-kolaka-dilarikan-ke-puskesmas/. (2018)
20. Supriadi B. Terungkap, Ini Hasil Lab Ikan Tongkol yang Bikin 410 Warga Jember Keracunan [*Laboratory results of suspected fish causing poisoning of 410 Jember citizen were revealed*] https://regional.kompas.com/read/2020/01/23/15412961/terungkap-ini-hasil-lab-ikan-tongkol-yang-bikin-410-warga-jember-keracunan?page=all. (2020)
21. Antara. Keracunan Ikan Tongkol, Tiga Orang Masih Dirawat [*Fish poisoned, three people were hospitalized*]. Jawapos. https://www.jawapos.com/jpg-today/12/03/2020/keracunan-ikan-tongkol-tiga-orang-masih-dirawat/ (2020)
22. Chendaki B. Polisi Usut Keracunan Ikan Tongkol BPNT Pemalang [*Police investigates BPNT fish poisoning in Pemalang*] https://www.puskapik.com/10690/berita/polisi-usut-keracunan-ikan-tongkol-bpnt-pemalang/ (2020)
23. Suryono. Ratusan Orang di Pemalang Diduga Keracunan Ikan Tongkol [*Hundreds of people in Pemalang were suspected to have fish poisoning*]. https://news.okezone.com/read/2020/07/21/519/2249499/ratusan-orang-di-pemalang-diduga-keracunan-ikan-tongkol (2020)
24. Raharjo DB. Puluhan Warga Batang Diduga Keracunan Ikan Tongkol Bantuan Kemensos [*Dozens of Batang's citizens were allegedly poisoned after consuming bullet tuna from Ministry of Social Welfare*]. https://jateng.suara.com/read/2020/06/18/153943/puluhan-warga-batang-diduga-keracunan-ikan-tongkol-bantuan-kemensos (2020)
25. Knope K, Sloan-Gardner TS, Stafford RJ. Histamine fish poisoning in Australia, 2001 to 2013. Commun Dis Intell. **38**, E285-93 (2014)
26. Feldman KA, Werner SB, Cronan S, Hernandez M, Horvath AR, Lea CS, et al. A large outbreak of scombroid fish poisoning associated with eating escolar fish (*Lepidocybium flavobrunneum*). Epidemiol Infect. **133, 1**:29-33 (2005)
27. McCormick DF, Dick H, Othieno R, Davis L, Wellington L. Outbreaks of scombroid fish poisoning in Lothian. (Health Protection Scotland, UK, 2013)
28. BPS-Statistics Indonesia. Agricultural Producer Price Statistics of Animal Husbandry and Fishery Subsector 2019. (BPS-Statistics Indonesia, Jakarta, 2020)
29. Indonesian Ministry of Marine Affairs and Fisheries. Laporan Kinerja Kementerian Kelautan dan Perikanan [*Performance Report of the Ministry of Marine Affairs and Fisheries*] (Kementerian Kelautan dan Perikanan, Jakarta, 2018)
30. Ariani M, Suryana A, Suhartini SH, Saliem HP. Keragaan konsumsi pangan hewani berdasarkan wilayah dan pendapatan di tingkat rumah tangga [*Variations of animal-based food consumption by regions and income in household level*]. (2018)

31. Virgantari F, Daryanto A, Kuntjoro SU. Dinamika konsumsi produk perikanan di indonesia. Ekologia: Jurnal Ilmiah Ilmu Dasar dan Lingkungan Hidup. **11**, 2:22-30 (2017)
32. United States Department of Health Human Services, Food Drug Administration, Center for Food Safety Applied Nutrition. Fish and fishery products hazards and controls guidance. Fourth ed. (Florida Sea Grant, Gainsville, 2011)
33. Indonesian National Standardization Agency. Ikan segar [Fresh fish]. Standar Nasional Indonesia. (Badan Standardisasi Nasional, Jakarta, 2013)
34. Canadian Food Inspection Agency. Fish product standards and methods manual. (2017)
35. Food Standard Australia New Zealand. Australia New Zealand Food Standards Code – Schedule 19 – Maximum levels of contaminants and natural toxicants. (2017)
36. Commission Regulation (EC) no. 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs, (2005).
37. Tsai Y-H, Hsieh H-S, Chen H-C, Cheng S-H, Chai T-j, Hwang D-F. Histamine level and species identification of billfish meats implicated in two food-borne poisonings. Food Chem. **104,** 4:1366-71 (2007)
38. Kan K, Ushiyama H, Shindo T, Uehara S, Yasuda K. Outbreak of histamine poisoning due to ingestion of fish, "Abura-sokomutsu" (*Lepidocybium flavobrunneum*). Shokuhin Eiseigaku Zasshi = Journal of the Food Hygienic Society of Japan. **41,** 2:116-21 (2000)
39. Emborg J, Dalgaard P, Kjølby A, Sørensen ND, Larsen IK. Results of biogenic amine concentrations and microflora in seafood causing histamine fish poisoning (HFP). Report No.: 3.4.2 (2008)
40. Chen H-C, Huang Y-R, Hsu H-H, Lin C-S, Chen W-C, Lin C-M, et al. Determination of histamine and biogenic amines in fish cubes (*Tetrapturus angustirostris*) implicated in a food-borne poisoning. Food Control. **21,** 1:13-8 (2010)
41. Awazu K, Takatori S, Kakimoto S, Nomura C, Masayama A, Yamaguchi M, et al. Detection of Histamine in Fish and Fishery Products in Osaka Prefecture (Fiscal 2015 Report). Food Hyg Saf Sci. **58**,1:43-8 (2017)\
42. Chen HC, Lee YC, Lin CM, Hwang DF, Tsai YH. Determination of histamine and bacterial isolation in marlin fillets (*Makaira nigricans*) implicated in a foodborne poisoning. J Food Saf. **30,** 3:699-710 (2010)
43. Lee Y-C, Huang T-C, Lin C-S, Lin C-M, Tsai Y-H. Determination of histamine and histamine-forming bacteria in Striped marlin fillets (*Tetrapturus audax*) implicated in a food-borne poisoning. Toxicon. **60**, 2:161-2 (2012)
44. Tsai YH, Kung HF, Lee TM, Chen HC, Chou SS, Wei CI, et al. Determination of histamine in canned mackerel implicated in a food borne poisoning. Food Control. **16,** 7:579-85 (2005)
45. Hwang CC, Tseng PH, Lee YC, Kung HF, Huang CY, Chen HC, et al. Determination of histamine in Japanese Spanish Mackerel (*Scomberomorus niphonius*) meat implicated in a foodborne poisoning. J Food Prot. **82**, 10:1643-9 (2019)
46. Tsai YH, Kung HD, Lee TM, Lin GT, Hwang DF. Histamine-related hygienic qualities and bacteria found in popular commercial scombroid fish fillets in Taiwan. J Food Prot. **67,** 2:407-12 (2004)
47. Lee Y-C, Kung H-F, Wu C-H, Hsu H-M, Chen H-C, Huang T-C, et al. Determination of histamine in milkfish stick implicated in food-borne poisoning. Journal of Food and Drug Analysis. **24,** 1:63-71 (2016)
48. Chen HC, Lee YC, Hwang DF, Chiou TK, Tsai YH. Determination of histamine in mahi-mahi fillets (*Coryphaena hippurus*) implicated in a foodborne poisoning. J Food Saf. **31,** 3:320-5 (2011)

49. Adams B, Langley A. Scombroid poisoning on the Sunshine Coast. Environmental Health. **4**, 2:50-4 (2004)
50. McLaughlin J, Gessner BD. Outbreak of Scombroid Poisoning – Anchorage (State of Alaska Epidemiology Bulletin. 2008)
51. Miki M, Ishikawa T, Okayama H. An outbreak of histamine poisoning after ingestion of the ground saury paste in eight patients taking isoniazid in tuberculous ward. Intern Med. **44,** 11:1133-6 (2005)
52. Chang SC, Kung HF, Chen HC, Lin CS, Tsai YH. Determination of histamine and bacterial isolation in swordfish fillets (*Xiphias gladius*) implicated in a food borne poisoning. Food Control. **19,** 1:16-21 (2008)
53. Otani N, Asano T, Mochizuki T, Shiino Y, Aoki M, Ishimatsu S. Outbreak of histamine poisoning associated with eating cooked swordfish. Nihon Kyukyu Igakukai Zasshi. **15**, 12:636-40 (2004)
54. Petrovic J, Babic J, Jaksic S, Kartalovic B, Ljubojevic D, Cirkovic M. Fish product–borne histamine intoxication outbreak and survey of imported fish and fish products in Serbia. J Food Prot. **79**, 1:90-4 (2016)
55. Guly HR, Grant IC. Case of the month: Lesson of the week: don't forget scombroid. Emergency medicine journal : EMJ. **23**, 12:955-6 (2006)
56. Becker K, Southwick K, Reardon J, Berg R, MacCormack J. Histamine poisoning associated with eating tuna burgers. JAMA. **285**, 10:1327-30 (2001)
57. Chen H-C, Kung H-F, Chen W-C, Lin W-F, Hwang D-F, Lee Y-C, et al. Determination of histamine and histamine-forming bacteria in tuna dumpling implicated in a food-borne poisoning. Food Chem. **106**, 2:612-8 (2008)
58. Hongchumpon N, Ouppapong T, Pungsakul J, Hanta A, Pawan W, Chalamaat M, et al. Scombrotoxin food poisoning outbreak among frozen seafood factory workers Samut Prakan Province, Thailand, July 2007. OSIR Journal. **2**, 1:5-8 (2016)
59. Predy G, Honish L, Hohn W, Jones S. Was it something she ate? Case report and discussion of scombroid poisoning. Can Med Assoc J. **168**, 5:587-8 (2003)
60. Jantschitsch C, Kinaciyan T, Manafi M, Safer M, Tanew A. Severe scombroid fish poisoning: An underrecognized dermatologic emergency. J Am Acad Dermatol. **65**, 1:246-7 (2011)
61. D'Aloia A, Vizzardi E, Della Pina P, Bugatti S, Del Magro F, Raddino R, et al. A scombroid poisoning causing a life-threatening acute pulmonary edema and coronary syndrome in a young healthy patient. Cardiovasc Toxicol. **11,** 3:280-3 (2011)
62. Demoncheaux JP, Michel R, Mazenot C, Duflos G, Iacini C, Delaval F, et al. A large outbreak of scombroid fish poisoning associated with eating yellowfin tuna (Thunnus albacares) at a military mass catering in Dakar, Senegal. Epidemiol Infect. **140,** 6:1008-12 (2012)
63. Ohnuma S, Higa M, Hamanaka S, Matsushima K, Yamamuro W. An outbreak of allergy-like food poisoning. Intern Med. **40,** 8:833-5 (2001)
64. Hall M. Something fishy: Six patients with an unusual cause of food poisoning! Emerg Med. **15,** 3:293-5 (2003)
65. Velut G, Delon F, Merigaud JP, Tong C, Duflos G, Boissan F, et al. Histamine food poisoning: a sudden, large outbreak linked to fresh yellowfin tuna from Reunion Island, France, April 2017. Eurosurveillance. **24,** 22:26-33 (2019)
66. Emborg J, Laursen BG, Dalgaard P. Significant histamine formation in tuna (*Thunnus albacares*) at 2°C - effect of vacuum- and modified atmosphere-packaging on psychrotolerant bacteria. Int J Food Microbiol. **101**, 3:263-79 (2005)
67. Kang CR, Kim YY, Lee JI, Joo HD, Jung SW, Cho S-I. An Outbreak of Scombroid Fish Poisoning Associated with Consumption of Yellowtail Fish in Seoul, Korea. J Korean Med Sci. **33**, 38:e235-e (2018)

68. Bulushi IA, Poole S, Deeth HC, Dykes GA. Biogenic amines in fish: Roles in intoxication, spoilage, and nitrosamine formation—A Review. Crit Rev Food Sci Nutr. **49**, 4:369-77 (2009)
69. Rodriguez-Jerez JJ, Mora-Ventura MT, Lopez-Sabater EI, Hernandez-Herrero M. Histidine, Lysine and Ornithine Decarboxylase Bacteria in Spanish Salted Semi-preserved Anchovies. J Food Prot. **57,** 9:784-7 (1994)
70. BPS-Statistics Indonesia. Food and Beverage Service Activities Statisticts, 2017 (BPS-Statistics Indonesia, Jakarta, 2019)