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Identification of histamine in fish and fish products in Poland during 2014–2018

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Abstract

Introduction: Histamine is one of the most important and toxic biogenic amines which may be present in food and may cause food poisoning in humans when contained at a high level. It is produced during bacterial decarboxylation of histidine in fish muscles. The aim of the study was to investigate the presence of histamine in fish and fish products available in Poland during 2014–2018. **Material and Methods:** A total of 421 samples of raw (248), smoked (107), canned (50), and marinated fish (16) were analysed by high-performance liquid chromatography with diode array detection. **Results:** Histamine was detected in 14.1% samples of raw fish, 29% of smoked fish, 22% of canned fish and 93.8% of marinated fish in concentrations ranging from 3.4 to 156.4 mg/kg. Content of this amine above 100 mg/kg was found in four samples: raw Atlantic salmon, smoked European sprat and two samples of marinated Atlantic herring. **Conclusion:** The study showed that fish and fish products on the Polish market generally meet the food safety criteria for histamine and are safe for consumers.

Keywords: histamine, fish, fish products, histamine fish poisoning, chromatography.

Introduction

Histamine is a heterocyclic biogenic amine formed during decarboxylation of amino acids or amination and transamination of aldehydes and ketones (14, 27). This biogenic amine naturally occurs in many species of fish with dark meat, especially of the following families: *Scombridae*, *Clupeidae*, *Engraulidae*, *Coryphaenidae*, *Pomatomidae*, and *Scomberesocidae* (7, 15, 16). Histamine is produced in fish by bacteria secreting the enzyme histidine decarboxylase, especially *Morganella morganii* and *Photobacterium phosphoreum* (8, 12, 17). Exposure of fresh fish to elevated temperatures enhances the growth of histidine decarboxylase-producing bacteria, and thus increases the histamine level (19). The purity of ice used to refrigerate fish is also important because it can be a source of histamine-producing bacteria (7).

Histamine is one of the most important biogenic amines in food hygiene because it causes a toxic effect in humans and has been shown to be a potential precursor of carcinogenic N-nitroso compounds (14). Research has demonstrated that fish and fish products containing high concentrations of histamine may pose a health risk to humans if consumed (19). Histamine fish poisoning, also known as scombrotoxic poisoning, is associated with the consumption of contaminated fish of the *Scombridae* family such as tuna, mackerel, and herring. Food poisoning of this specific type is frequently observed among people at high risk of allergic reaction (11) and intoxicated persons should receive treatment similar to that for seafood allergies (10). The symptoms of scombrotoxic poisoning usually resolve within 24 h, mainly because of a detoxification system in the intestinal tract, which is able to metabolise low amounts of histamine by monoamine and diamine oxidase enzymes (1, 13, 18, 28). However, when there has been intake of a high amount of histamine, this system is unable to eliminate the amine sufficiently (4, 14).

The aim of the present study was to investigate the presence and level of histamine in fish and fish products available in Poland during 2014–2018.

Material and Methods

A total of 421 samples of fish and fish products were tested for the presence of histamine. Samples were purchased directly from manufacturers and from various local retail markets in the Puławy region of Poland. The

investigation covered raw fish (248 samples), smoked fish (107), canned fish (50), and marinated fish (16) of the species shown in Tables 1 and 2. After purchasing, the samples were immediately delivered to the laboratory chilled.

Histamine content was determined using high performance liquid chromatography with a diode detector (Varian ProStar 330, the Netherlands) according to the authors' validated and accredited procedure described previously (21). Briefly, histamine was extracted from samples with trichloroacetic acid and purified using Strata-X-AW ion-exchange SPE cartridges (Phenomenex, Torrance, CA, USA). Chromatographic separation was performed on a C18 column (Agela Technologies, Torrance, CA, USA), with a detection wavelength of λ = 215 nm. The limit of detection was 2.1 mg/kg, limit of quantification was 3.3 mg/kg, and the range of the method was 3.3–420 mg/kg (21).

Results

The results of the histamine analysis in raw fish samples are shown in Table 1. Among the total of 248 such samples, histamine was detected in 35 (14.1%). The concentration of the amine ranged from 3.4 to 156.4 mg/kg, with the highest being found in Atlantic salmon (156.4 mg/kg) and Atlantic herring (42.5 mg/kg). No detectable level of this amine was identified in the remaining 213 raw fish samples tested (Table 1).

Table 1. The content of histamine in raw fish

Species	Number of samples tested	Number (%) of positive samples	Range (mg/kg)
European sprat (*Sprattus sprattus*)	31	13 (41.9)	4.0–23.8
Atlantic cod (*Gadus morhua morhua*)	36	9 (25)	5.0–12.3
Atlantic salmon (*Salmo salar*)	34	8 (23.5)	3.6–156.4
Atlantic herring (*Clupea harengus*)	32	2 (6.25)	8.0, 42.5
Alaska pollock (*Theragra chalcogramma*)	12	2 (16.7)	11.3, 3.4
Yellowfin sole (*Limanda aspera)*	8	1 (12.5)	7.07
Atlantic mackerel (*Scomber scombrus*)	23	0	-
Rainbow trout (*Oncorhynchus mykiss*)	20	0	-
European hake (*Merluccius merluccius*)	10	0	-
Torpedo scad (*Megalaspis cordyla*)	7	0	-
Flounder (*Platichthys flesus*)	6	0	-
Other[1)]	29	0	-
Total	248	35 (14.1)	3.4-156.4

[1)]Turbot(*Scophthalmus maximus*), gilthead seabream (*Sparus aurata*), carp (*Cyprinus carpio carpio*), pike-perch (*Sander lucioperca*), Nile tilapia (*Oreochromis niloticus*), Atlantic halibut(*Hippoglossus hippoglossus*), Atlantic wolffish(*Anarhichas lupus*),freshwater bream (*Abramis brama*),swordfish (*Xiphias gladius*), common warehou (*Seriolella brama*),whiting (*Merlangius merlangus*), European perch (*Perca fluviatilis*), and blue grenadier (*Macruronus novaezelandiae*)

Table 2. The content of histamine in smoked, canned and marinated fish

Species	Number of samples tested	Number (%) of positive samples	Range (mg/kg)
Smoked fish			
Atlantic mackerel	17	11 (64.7)	4.1–41.1
Atlantic salmon	16	5 (31.3)	3.8–39.5
European sprat	14	11 (78.6)	20.1–125.8
Rainbow trout	13	1 (7.7)	3.5
Atlantic halibut	13	1 (7.7)	8.9
Atlantic wolffish	5	2 (40)	9.7, 3.7
Atlantic cod	16	0	-
Atlantic herring	7	0	-
Other[1)]	6	0	-
Total	107	31 (29.0)	3.5–125.8
Canned fish			
Atlantic mackerel	9	3 (33.3)	3.4–14.0
European sprat	19	3 (15.8)	4.8–17.0
Bonito (*Katsuwonus pelamis*)	13	4 (30.8)	4.2–17.0
Atlantic herring	9	1 (11.1)	4.6
Total	50	11 (22)	3.4–17.0
Marinated fish			
Atlantic herring	16	15 (93.8)	4.2–122

[1)] European hake (*Merluccius merluccius*) (3 samples), oilfish (*Ruvettus pretiosus*) (3 samples)

Table 2 shows the results of histamine investigation in smoked, canned, and marinated fish. A total of 107 smoked fish samples were examined and in 76 (71%) of them histamine was not detected. In the remaining 31 (29%) samples the content of histamine ranged from 3.5 mg/kg (rainbow trout) to 125.8 mg/kg (European sprat).

Of the 50 samples of canned fish, histamine was identified in 11 (22%) in concentrations from 3.4 mg/kg (Atlantic mackerel) to 17 mg/kg (European sprat and bonito) (Table 2). In marinated fish products (Atlantic herring), histamine was detected in 15 of the total of 16 (93.8%) samples, with the concentration ranging from 4.2 to 122 mg/kg (Table 2).

Among a total of 421 fish and fish product samples tested, histamine was identified in 92 (21.9%). Content of the amine above 100 mg/kg was found in four (1%) samples: raw Atlantic salmon, smoked European sprat and two samples of marinated Atlantic herring (Tables 1 and 2).

Discussion

Worldwide, histamine fish poisoning is the most frequently involved factor in ichythyotoxicosis and follows the consumption of meat of *Scombridae* and *Scomberesocidae* species that contains high levels of histamine (10). The study by Bartholomew *et al*. (3) showed that histamine content <50 mg/kg did not cause any toxic effect, whereas levels of 50–200 mg/kg are possibly toxic, 200–1000 mg/kg are probably toxic, and >1000 mg/kg are definitely toxic and unsafe for consumers. According to other data, ingestion of food containing a small amount of histamine from 8 to 40 mg can cause slight poisoning symptoms, an amount of over 40 mg results in moderate manifestations, and a dose of 100 mg poisons a person severely (28, 30). Regulation No. 2073/2005 of the European Union Commission of November 15, 2005 on the microbiological criteria for foodstuffs limits the content of histamine in fish and fish products to 100-200 mg/kg (6).

Determination of histamine is important not only due to its toxicity to humans, but also as an indicator of the freshness of fish and fish products (14). Therefore, studies on the content of histamine in food are conducted in many countries around the world. Scombroid poisoning was first described in 1799 in Great Britain and re-emerged in the 1950s when histamine was reported in Japan as a major cause of foodborne disease outbreaks at that time (3, 10). Data available in the Rapid Alert System for Food and Feed (RASFF) reports from 2014–2018 from EU countries show 79 notifications of excessive levels of histamine in fish and fish products. The concentration of histamine ranged from 111 to 6860 mg/kg, and this contamination was mainly in tuna fillets from Spain (22–26). According to the RASFF annual report for 2014, the majority of histamine notifications were related to fresh or frozen fish stored at insufficiently low temperatures (22). Refrigeration aboard fishing vessels is critical for the control of bacterial histamine formation. Ideally, fish should be kept at 0°C or below to prevent bacteria growth at this temperature histidine decarboxylase is not activated. It has been shown that toxic levels of histamine can be formed during 2–3 h of fish storage at 20°C or higher temperatures (10, 11).

Studies on histamine content in fish and fish products similar to those investigated in the present experiments were carried out in Korea, and this amine was detected in 48.7% of the samples (20). The highest level of histamine was found in anchovies (70.1 mg/kg) and in mackerel (39.3 mg/kg). In a survey conducted in Togo, West Africa, Bouka *et al.* (5) reported, that 100% of smoked fish samples collected from wholesalers in three different markets contained high amounts of histamine, with mean concentrations of 746.54 mg/kg, 472.37 mg/kg, and 295.06 mg/kg, respectively. This means that none of them met the requirements of the European Commission Regulation No. 2073/2005 (6). In Taiwan, Tsai *et al*. (29) analysed 61 samples of scombroid fish fillets sold in traditional retail markets, and 6.5% of them contained histamine at concentrations ranging from 128 to 288 mg/kg. In Cape Town, South Africa, histamine levels in fresh fish were low, at 0–9 mg/kg, with the exception of two samples with content above 50 mg/kg (2). Processed fish products also had low histamine concentrations of 0–3 mg/kg, except for 6% of the samples, which contained histamine above 50 mg/kg (2). In a survey conducted in Turkey, Erkan *et al*. (9) reported, that among 39 canned fish samples from the retail market tested for histamine, 7.7% contained more than 1,000 mg/kg of this amine. In different countries, diverse types of fish contained variable levels of histamine, with higher amounts associated with fish responsible for outbreaks or incidents and lower levels in randomly selected samples (30).

The present study showed that the raw fish and fish products offered on the Polish market generally met the food safety criteria for histamine listed in Commission Regulation (EC) No. 2073/2005 and are safe for consumers. However, our results demonstrate that a few samples contained more of the amine than the legal limit, which made them unsuitable for consumption. The priorities to prevent scombrotoxic poisoning are adequate refrigeration practices, adherence to international standards of food hygiene and appropriate fish processing procedures to prevent bacterial spoilage and the production of histamine (13, 18).

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References

1. Attaran R.R., Probst F.: Histamine fish poisoning: a common but frequently undiagnosed condition. Emerg Med J 2002, 19, 474–475, doi: 10.1136/emj.19.5.474.
2. Auerswald., Morren C., Lopata A.L.: Histamine levels in seventeen species of fresh andprocessed South African seafood. Food Chem 2006, 98, 231–239, doi: 10.1016/j.foodchem. 2005.05.071.
3. Bartholomew B.A., Berry P.R., Rodhouse J.C., Gilbert R.J., Murray C.K.: Scombrotoxic fish poisoning in Britain: Features of over 250 suspected incidents from 1976 to 1986. Epidem Inf 1987, 99, 775–782, doi: 10.1017/s0950268800066632.
4. Bodmer S., Imark C., Kneubühl M.: Biogenic amines in food: Histamine and food processing. Inflamm Res 1999, 48, 296–300, doi: 10.1007/s000110050463.
5. Bouka E.C., Lawson-Evi P., Idoh K., Paka E., Eklu-Gadegbeku K.: Analysis of microbiological and chemical risks in fresh and smoked fishes sold in Togo. Int J Environ Res Public Health 2020, 4, 242–248, doi: 10.22161/ijreh.4.6.4.
6. Commission of the European Communities: Commission Regulation (EC) No. 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. OJ, L.2005, 338, 48, 22/12/2005, 1–26.
7. Economou V., Brett M., Papadopoulou C., Frillingos S., Nichols T.: Changes in histamine and microbiological analyses in fresh and frozen tuna muscle during temperature abuse. Food Additives Contam 2007, 24, 820–832, doi: 10.1080/02652030701278321.
8. 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 2006, 69, 897–906, doi: 10.4315/0362-028X-69.4.897.
9. Erkan N., Helle N., Ozden O.: The content of biogenic amines in canned fish from the Turkish market (in German). Berl Munch Tierarztl Wochenschr 2001, 114, 241–245.
10. Feng Ch., Teuber S., Gershwin E.G.: Histamine (scombroid) fish poisoning: a comprehensive review. Clinic Rev Allerg Immunol 2016, 50, 64–69, doi: 10.1007/s12016-015-8467-x.
11. Gonzaga V.E., Lescano A.G., Huaman A.A., Salmón-Mulanovich G., Blazes D.L.: Histamine levels in fish from markets in Lima, Peru. J Food Prot 2009, 72, 1112–1115, doi: 10.4315/0362-028X-72.5.1112.
12. Halász A., Baráth Á., Simon-Sarkadi L., Holzapfel W.: Biogenic amines and their production by microorganisms in food. Food Sci Technol 1994, 5, 42–48, doi: 10.1016/0924-2244(94)90070-1.
13. Hungerford J.: Scombroid poisoning: A review. Toxicon 2010, 56, 231–243, doi: 10.1016/j.toxicon.2010.02.006.
14. Karovicova J., Kohajdova Z.: Biogenic amines in food. Chem Pap 2005, 59, 70–79.
15. Kim M.K., Mah J.H., Hwang H.J.: Biogenic amine formation and bacterial contribution in fish, squid and shellfish. Food Chem 2009, 116, 87–95, doi: 10.1016/j.foodchem.2009.02.010.
16. Lehane L., Olley L.: Histamine fish poisoning revisited. Int J Food Microbiol 2000, 58, 1–37, doi: 10.1016/S0168-1605(00)00296-8.
17. Masashi K., Tomoko Y., Masanori I., Teizo T.: Photobacterium phosphoreum caused a histamine fish poisoning incident. Int J Food Microbiol 2004, 92, 79–87, doi:10.1016/j.ijfoodmicro. 2003.08.019.
18. McLauchlin J., Little C.L., Grant K.A., Mithani V.: Scombrotoxic fish poisoning. J Public Health 2006, 28, 61–62, doi: 10.1093/pubmed/fdi063.
19. Papageorgiou M., Lambropoulou D., Morrison C., Kłodzińska E., Namieśnik J., Płotka-Wasylka J.: Literature update of analytical methods for biogenic amines determination in food and beverages. Trends Analyt Chem 2018, 98, 128–142, doi: 10.1016/j.trac.2017.11.001.
20. Park J.S., Lee Ch.H., Kwon E.Y., Lee H.J., Kim J.Y., Kim S.H.: Monitoring the contents of biogenic amines in fish and fish products consumed in Korea. Food Control 2010, 21, 1219–1226, doi: 10.1016/j.foodcont.2010.02.001.
21. Pawul-Gruba M., Michalski M., Osek J.: Determination of histamine in fresh and smoked fish commercially available in Poland. Bull Vet Inst Pulawy 2014, 58, 301–304, doi: 10.2478/bvip-2014-0046.
22. Rapid Alert System for Food and Feed:. Annual Report 2014. Publications Office of the European Union, Luxembourg 2015, pp. 13–23, doi: 10.2875/945461.
23. Rapid Alert System for Food and Feed:. Annual Report 2015. Publications Office of the European Union, Luxembourg 2016, pp. 11–17, doi: 10.2875/112129.
24. Rapid Alert System for Food and Feed:. Annual Report 2016. Publications Office of the European Union, Luxembourg 2017, p. 9, doi: 10.2875/022237.
25. Rapid Alert System for Food and Feed:. Annual Report 2017. Publications Office of the European Union, Luxembourg 2018, pp. 10–15, doi: 10.2875/767865.
26. Rapid Alert System for Food and Feed:. Annual Report 2018. Publications Office of the European Union, Luxembourg 2019, p. 14, doi: 10.2875/914558.
27. Santos M.: Biogenic amines: their importance in foods. Int J Food Microbiol 1996, 29, 213–231, doi:10.1016/0168-1605(95)00032-1.
28. Shalaby A.R.: Significance of biogenic amines to food safety and human health. Food Res Int 1996, 27, 765–690, doi: 10.1016/S0963-9969(96)00066-X.
29. Tsai Y.-H., Kung H.-F., Lee T.-M., Lin G.-T., Hwang D.-F.: Histamine related hygiene qualities and bacteria found in popular commercial scombroid fish fillets in Taiwan. J Food Prot 2004, 67, 407–412, doi: 10.4315/0362-028X-67.2.407.
30. Vosikis V., Papageoropoulou A., Economu V., Frillingos S., Papadopoulou C.: Survey of the histamine content in fish samples randomly selected from the Greek retail market. Food Additives Contam 2008, 1, 122–129, doi: 10.1080/02652030802527147.