



Hidden hazards in seafood: Histamine poisoning

Kalli Vasanthi^{1*} and Kinnera Tejaswini²

¹ – PhD Scholar, Department of Fish Processing Technology, ICAR-CIFE, Mumbai

² – PhD Scholar, Department of Fish Nutrition and Feed Technology, ICAR-CIFE, Mumbai

Corresponding author email id: Vasanthi.phtpb104@cife.edu.in

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Abstract

Though Seafood is highly valued for its nutritional significance, it also harbors several hidden hazards if not handled in a proper manner. One such potential hazard is histamine poisoning, otherwise termed as scombroid poisoning. This is due to accumulation of histamine in the muscle produced as a result of decarboxylation of histidine. Improper storage temperature and presence of microbes act as potentiators for histamine accumulation. Histamine is highly stable to heat and is not eliminated by cooking, hence pose a significant threat in food. Prevention of histamine poisoning is mostly dependent on maintenance of cold chain and proper handling. This present article provides a comprehensive overview on the significance, causes, symptoms of histamine poisoning, bacteria associated along with its association with commonly consumed fish species. By understanding the underlying mechanisms and preventive strategies, the risks posed due to histamine in seafood can be effectively minimized or eliminated thus ensuring safer food to the people.

Key words: Hazard, Histamine, Seafood

Introduction

Histamine (C₅H₉N₃) is a biogenic amine produced in fish tissue due to decarboxylation of free histidine in muscle by the histidine decarboxylase enzyme (HDC) (Ladero *et al.*, 2010). Endogenously produced histamine in fish tissues by the mast cells and basophils is very small compared to the amount produced by HDC enzyme released by microorganisms in fish tissue. Histamine-producing bacteria are generally introduced in fish muscle as a result of contamination, i.e., before, during, or after the processing of fish. Histamine in human body is physiologically degraded into imidazole acetaldehyde, ammonia and hydrogen peroxide catalyzed by histamine oxidase or histamine dehydrogenase (Sekiguchi *et al.*, 2004). Histamine belongs to class of imidazoles, i.e. 1H-imidazole substituted by 2-aminoethyl group at C-4

position. Fishes belonging to families of *Scomberesocidae* and *Scombridae* were found to have greater histidine content in their muscle tissue (Rawles *et al.*, 1996). Histamine Fish Poisoning (HFP) is most commonly associated with scombroid fishes such as tuna, seer fish, mackerel, bonito, etc., but nowadays, many non-scombroid fish such as anchovies, pilchards, marlines, sardines, and herrings are also reported as agents of HFP due to the presence of high amounts of histamine in their muscle tissue (Taylor, 1986; Lehane and Olley, 2000). Histamine poisoning is toxicologically important as it is always misdiagnosed with other allergy-like symptoms (Hajeb and Selamat, 2012).

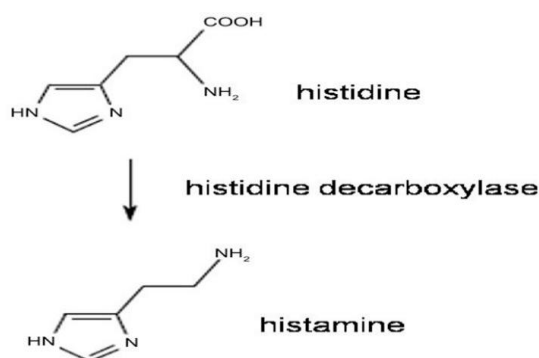


Fig.1. Chemical structure of Histidine and Histamine

Significance of Histamine poisoning pertaining to public health

Histamine poisoning otherwise, known as Scombroid fish poisoning, is one of the leading and most common toxicity caused due to fish consumption (Dalgaard and Emborg, 2008). It was first reported in the year 1799 in Britain (Halstead, 1965). It often occurs due to consumption of improperly processed or stored food with higher histamine contents. It is mostly self-limiting (Stratta and Badino, 2012). Onset time ranges from few minutes to 3hours after consuming fish with >100mg/100g (Tembhurne *et al.*, 2013). Details of symptoms associated with poisoning were outlined in Table 1.

Table.1. Symptoms associated with different histamine poisoning (Visciano *et al.*, 2020)

Body Part	Symptoms
Cardiovascular	Hypotension with distributive shock, cardiac arrhythmias, myocardial dysfunction, acute pulmonary oedema, oral numbness, tingling
Neurological	Throbbing headache, migraines, dizziness, faintness, loss of sight, anxiety, tremor

Integumentary	Face, neck, and upper arm flushing, itchy rash, hives, localized swelling, redness, Urticaria, pruritus
Gastrointestinal	Abdominal pain, stomach cramps, nausea, vomiting, diarrhoea
Respiratory	Asthma attacks, respiratory distress, rhinitis, bronchoconstriction, dyspnoea
Other	Metallic or peppery taste, oral numbness, difficulties in swallowing and thirst, feeling of warmth around the mouth

Microflora associated with histamine poisoning

Histamine forming bacteria (HFB) are primary inhabitants of gills and gut of fishes and generally account for about 1% of natural micro flora from tuna (Kose, 2010). Most of them come under families belonging to Bacillaceae and Enterobacteriaceae. Specific histamine production rate of these bacteria differ among species (Sumner *et al.*, 2004). *M.morganii*, *P.vulgaris*, *K.pneumoniae*, *E.coli*, *H.alvei*, *E.aerogenes*, *K.oxytoca*, *P.mirabilis* the members of Enterobacteriaceae have been recognised as prolific histamine formers (Tembhurne *et al.*, 2013). Some strains of lactic acid bacteria (*Lactobacillus*, *Pediococcus*, and *Streptococcus*) are capable of synthesizing histamine due to presence of histidine decarboxylase enzyme (Kuley *et al.*, 2013).

Role of biogenic amines in histamine poisoning

Other biogenic amines found in the fish tissue play a significant role in determining histamine toxicity. Biogenic amines found in seafood include cadaverine, putrescine, histamine, tyramine, spermine and phenylethyl amine. Cadaverine present in fish muscle can act as a potentiator for inducing histamine toxicity there by leading to scombroid poisoning (Bulushi, *et al.*, 2009). Cadaverine and putrescine if present along with histamine can increase histamine toxicity by inhibiting histamine metabolizing enzymes such as diamine oxidase and histamine N-Methyl Transferase (Middlebrooks *et al.*, 1988; Hungerford, 2010). Presence of other amine producing microbes along with histamine formers can increase levels of histamine production. In public health context, amines in the muscle is often considered as a quality index, commonly termed as Biogenic amine index (Prester, 2011).

Outbreaks

Largest outbreak in the world till date was recorded in Japan in the year 1973 involving 2656 cases caused due to the consumption of dried mackerel (Taylor, 1986). Since 1970, histamine intoxication cases were most reported from Japan, UK and United States. Histamine poisoning outbreaks between 2005 and 2010 were more than 100 cases (EFSA, 2011). By the

year 1997, histamine poisoning was reported as major seafood borne illness in United States (Lipp and Rose, 1997).

Detection techniques

List of available techniques to detect histamine and their detection limits were given in Table 2.

Table 2. Different methods used to detect histamine (Ruiz-Capillas and Herrero, 2019)

Detection Methods	Sensitivity detection limit
Ninhydrin Assay	25nmoles/ml
Gas chromatography	<1.1µg/g
High pressure liquid chromatography (HPLC)	0.5ppm
Ion exchange chromatography	0.15-0.5mg/kg
Spectro-fluometric method	0.8-6mg/kg
ELISA kit	10-20ng/ml
Rapid sensors- BIOFISH 300, BIOFISH 700, HistaStrip	6ppm
Exiting Ultra HPLC	0.01-0.1mg/kg
Thin Layer Chromatography(TLC)	5ng-10ng

Acceptable limits

Levels of acceptance vary from region to region. Maximum histamine permissible level according to Australian New Zealand Food Standards is 200 mg/kg (Biji *et al.*, 2016). According to FSSAI standards 200mg/kg histamine is acceptable in fresh, dried, smoked, minced, battered and breaded fishery products whereas 400mg/kg is acceptable in fermented fish products (FDA, 2018). According to Codex Alimentarius Commission maximum permissible limit is 200mg/kg with special reference to fishes of families *Clupeidae*, *Scombridae*, *Scomberesocidae*, *Pomatomidae* and *Coryphaenidae* (Visciano *et al.*, 2020).

Control strategies to prevent histamine formation

Shakila *et al.* (2003) found no correlation between histamine formation and sensory evaluation during fish storage at ambient temperature. Maintenance of proper cold chain from

catch to consumption can reduce histamine formation to a very significant level (Silva *et al.*, 2011). Gutting of larger size fishes (>9.1kg) and immediate bleeding after catch can reduce histamine and improve meat quality (FDA, 2011).

Temperature is the most crucial factor responsible for elevated histamine levels in fishes, hence fishes caught has to be immediately chilled before further processing (Emborg and Dalgaard, 2008). Precooking could be a very useful method to control histamine and no increase in histamine was found in precooked tuna samples after 12 to 18 hours (Adams *et al.*, 2018). pH modification using Tri Sodium Phosphate can reduce histamine levels (Hoang *et al.*, 2021). Treatment with rosemary plant extract (*Rosmarinus officinalis*) on sword fish fillets and vacuum packing helped in reducing histamine levels to regulatory limits during 16 day storage period (Anastasio *et al.*, 2014). Irradiation treatment at 2kGy can eliminate histamine forming bacteria from tuna flesh whereas irradiation at 1.5kGy can reduce histamine formers by 4 to 5 log₁₀CFU in tuna flesh (Ramakrishnareddy *et al.*, 2020).

Conclusion

Biogenic amines, especially histamine still remains to be a matter of concern in context of seafood. Fishes inherently have varied concentrations of histidine in their muscle, which gets converted into histamine if improperly stored. Histamine formation is dependent on several factors such as temperature, handling and microflora associated. It was found that gram negative bacteria play a role in potentiating histamine poisoning. Outbreaks due to histamine poisoning were a concern of seafood safety as this toxin is highly heat stable and hence adoption of preventive strategies only remain a viable solution in preventing the disease. If properly handled and maintained, histamine poisoning can be reduced or eliminated to a larger extent in the seafood.

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