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A Mini Review: Histamine Concentration in Freshwater and Marine Fishes

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Abstract

Marine ecosystems are aquatic environments with high levels of dissolved salt, such as those found in or near the ocean. Marine ecosystems are defined by their unique biotic (living) and abiotic (non-living) factors. Biotic factors include plants, animals, and microbes; important abiotic factors include the amount of sunlight in the ecosystem, the amount of oxygen and nutrients dissolved in the water, proximity to land, depth, and temperature. Sunlight is one of the most important a biotic factor for marine ecosystems. It's so important that scientists classify parts of marine ecosystems up to three by the amount of light they receive. The topmost part of a marine ecosystem is the euphotic zone, extending down as far as 200 meters (656 feet) below the surface. At this depth, there is sufficient light for regular photosynthetic activity and most of the marine life inhabits this zone. Below the euphotic zone is the dysphotic zone, which can reach from 200 to as deep as 1,000 meters (656 to 3,280 feet) below the surface. At these depths, sunlight is still available, but only enough to facilitate some photosynthesis. Below the dysphotic zone lays the aphotic zone, which does not receive any sunlight. Marine ecosystems are characterized by the biological community of an organism that they are associated with and their physical environment. - Classes of an organisms found in marine ecosystems include brown algae, dinoflagellates, corals, cephalopods, echinoderms, and sharks. Marine ecosystems are important sources of ecosystem services and food and jobs for significant portions of the global population. This mini review will focus on histamine concentration in freshwater and marine fishes.

Keywords: Ocean, Aquatic Sciences, Freshwater, Marine Fishes

Introduction

Freshwater Ecosystem

Freshwater ecosystems naturally share resources between habitats. The ecosystems in rivers and streams, for example, bring salts and nutrients from the mountains to lakes, ponds, and wetlands at lower elevations, and eventually, they bring those nutrients to the ocean. These waterways also enable migrating species, like salmon, to bring nutrients from the ocean to upstream freshwater ecosystems. Lakes and ponds, on the other hand, can exchange nutrients in a seasonal cycle. Cold water is denser than warm water, so it sinks to the bottom, where a fairly steady temperature is maintained. However, as the air temperature drops with the arrival of winter, the water that is closest to the surface may drop below the temperature of the water at the bottom of the lake, causing it to sink and the warmer bottom water to rise. The same process happens as floating surface ice melts into very cold water in the spring. During these periods, nutrients are churned from the floor and brought to the surface. It is normal for ecosystems to encounter change [27].

Histamine

Histamine (2-[4-imidazolyl] ethylamine) is a bioactive amine that is synthesized by decarboxylation of its precursor amino acid, histidine, in an enzymatic reaction first described by Windaus and Vogt in 1907 involving L-histidine decarboxylase. Due to its chemical structure and number of functional groups, histamine can be defined as a heterocyclic diamine with an imidazole ring and ethylamine (i.e., an organic compound that provides a functional group in the form of a primary amine). Specifically, histamine is synthesized and stored in high concentrations in secretory granules, mainly in basophiles and mast cells, and also in gastric enterochromaffin cells, lymph nodes and the thymus. Functionally, this amine is involved in various immune and physiological mechanisms, stimulating gastric acid secretion, inflammation, smooth muscle cell contraction, and vasodilation and cytokine production, among other processes. In addition, histamine functions as a neurotransmitter, being synthesized by neurons located in the posterior region of the hypothalamus whose axons extend through the brain [8]

Histamine in Fish

Histamine is a biogenic amine produced in fish tissue through the decarboxylation of free histidine by exogenous decarboxylase released by microorganisms. This ability has been described in different genera, species, and strains of bacteria, both Gram positive and Gram negative. Histamine is rarely found in fresh fish but its level increases with the progress of fish decomposition. The microorganisms naturally present on the gills and in the gut of live fish start to grow upon death because the defence mechanisms are inactive. In particular histamine forming bacteria are able to grow more rapidly at high abuse than at moderate abuse temperatures. However once the enzyme histidine decarboxylase has been formed, it can continue to produce histamine also at or near refrigeration temperature, it remains stable in frozen fish and can be reactivated after thawing. Frozen temperature (-18°C or below) can stop the growth of bacteria and prevent any preformed histidine decarboxylase from producing histamine. Histamine poisoning is a food-borne disease characterized by a variety of symptoms similar to allergic reactions. The toxic effects of histamine are related to its normal physiological actions in the body. In particular the dilatation of the peripheral blood vessels results in hypotension, flushing, and headache, while the increased capillary permeability causes urticaria, hemoconcentration, and eyelids edema; the symptoms affecting the gastrointestinal system are due to the contraction of smooth muscles leading to abdominal cramps, diarrhea, nausea, and vomiting [29].

Histamine Producing Bacteria

Many bacterial species are known to possess histidine decarboxylase enzyme and hence they can produce histamine. However, only bacteria such as Morgonella morganii, Klebsiella pneumonia, and Hafnia alvei have been isolated from spoiled scombroid fishes which are responsible for histamine fish poisoning. Several other enterobacteria and species of Clostridium, Bacillus, and Lactobacillus are capable of decarboxylating histidine. M. morganii and Enterobacter aerogenes, K.pneumoniae, K.planticola, Photobacterium phosphonium and P. histaminum have also been shown to possess strong histidine decarboxylase activity. Histamine production in fish is related to the histidine content of the fish, the presence of bacterial histidine decarboxylase, and environmental conditions (lenistea, 1973). During spoilage, certain bacteria produce decarboxylase enzymes, which act on free histidine and other amino acids in the fish muscle from histamine and other biogenic amines. Chemically, histamine, putrescine, cadaverine, spermidine, and spermine which are produced in post-mortem conditions in the fish muscle are low-molecular-weight, aliphatic, alicyclic or heterocyclic organic bases [10] Seafood is one of the essential sources of nutrients for the human diet. However, they can be subject to contamination and can cause food borne illnesses, including scombroid fish poisoning caused by histamine. Many microorganisms can produce enzymes that eventually decompose endogenous histidine to histamine in post mortem fish muscles and tissues. One of these is histamine-forming bacteria (HFB), primarily found in the gills, gut, and skin of fishes. Previous studies linked a plethora of Gram-negative HFB including *Morganella* spp. and *Photobacterium* spp [23].

GC Analysis in Histamine

Other authors report the use of GC as a tool for histamine analysis. These methods are, however, not suitable for each kind of food and often require several modifications. Arnold and Brown stated that despite the possibilities for the application of GC techniques, they have not achieved widespread use among researchers studying histamine intoxication. Histamine must be converted to some volatile derivative, which can then be separated by the GC. However, Mita [21] reported that some derivatives are unsuitable for histamine quantitation. A GC method using trimethylsilylation of histamine, and reported the trimethylsilyl derivative of histamine in tuna was readily resolved using a capillary column. Other derivatizing agents used are pentafluoropropionic anhydride and heptafluorobutyryl and ethyl chloroformate, and others may involve a combination with 2, 6-dinitro4-trifluoromethylbenzenesulfonic acid. Each of these methods uses one of several detectors [1]. In view of the above, there is a lack of analytical equipment and awareness among the fisherman and the manufacturers, and outbreaks of histamine fish poisoning occurred every year in different parts of the world. The most source of histamine food poisoning is fish and fishery products increased in the recent years with the total number of large victims of illness being reported. Therefore, this study is very useful for the public and seafood producers to detect the histamine health hazard in fishery products with a cost-effective method and minimize histamine outbreaks in the future and enhance food safety. Thus, the present study was carried out to determine and comparison the histamine level in freshwater fishes (*Catla catla, Oreochromis mossambicus*) and marine water fishes (*Clupea harengus, Rastrelliger kanagurta*) collected from local fish forms and retail stores in Annankovil landing centre region, Parangipettai, and Bhuvanagiri fish market, Chidambaram, Tamil Nadu, using GC method. Our study evaluates histamine concentration in freshwater and marine fish in stored conditions.

Biogenic Amines

Bilgin B [5] study (HPLC) was used to simultaneously assess the concentrations of 5 biogenic amines in 63 samples of fish products. Products made of fish were bought in many Turkish cities. Cans of tuna, mackerel, sardines, and marinated anchovies were among the fish samples. The range of biogenic amine concentrations was 26.58 to 406.55 mg/kg. The two most prevalent biogenic amines were histamine (HIS) and cadaverine (CAD). Tyramine (TYR) and HIS concentrations were below 50 and 100 mg/kg, respectively. It also investigated how pH levels, total volatile basic nitrogen (TVB-N), and thiobarbituric acid (TBA) affect the synthesis of biogenic amines in fish products. The pH of TBA and TVB-N had a substantial negative connection (p 0.01) with one another. TVB-N, pH, protein, CAD, TYR, and HIS In-fish samples, there were significant (p0.01) positive relationships between

the levels of TBA, TYR, tryptamine, pH, and TVB-N.

Histamine Concentration

Bangieva [4] were tasked with using enzyme-linked Immunosorbent assay (ELISA) kits to measure the histamine levels in freshwater and marine fish gathered from neighbourhood fish farms and retail establishments in the Stara Zagora area of Bulgaria. Histamine levels in freshwater and marine fish are indicative of their high grade. Nonetheless, a significant food safety issue still exists as a result of its presence in seafood, necessitating long-term management of histamine levels in fish.

Arulkumar [3] current study is based on the histamine levels of 20 muscle samples from Indian whiting (*Sillago indica*) and milkfish (*Chanos chanos*) were compared using an enzymatic assay (EA), thin layer chromatography (TLC), and high-performance liquid chromatography (HPLC) techniques at intervals of 6, 12, and 24 h. According to the EA method, the histamine levels in milkfish fluctuated during storage, with a linear regression coefficient and a significance threshold of 0.05. Histamine was detected at lower amounts using the TLC method as opposed to whiting muscle, respectively. Both fish showed a linear relationship. The HPLC study also confirmed that milkfish had histamine levels that ranged from a linear regression having an r2 value of 0.903 and a P-value of 0.01 for each. Histamine levels in Indian whiting fish ranged from 17.28 1.67 to 23.97 1.27 mg/100 g, with a linear regression having an r2 value of 0.910 and a P-value of 0.01. Hence, histamine monitoring is a crucial responsibility in the seafood sector. Our findings demonstrated that enzymatic analysis can be used to assess the levels of histamine in the seafood industry while TLC methods can be utilized to monitor the histamine content in routine analyses.

Duflos [9] studied that the Bacterial decarboxylase generates histamine from histidine in contaminated fish, leading to scombroid fish poisoning. The use of a Fully validated, standardized reference HPLC technique for histamine detection and quantification is required by European Regulation on Microbiological criteria for foodstuffs. In 2013, utilizing predetermined criteria for technique performance; we organized an inter-laboratory study including nine laboratories from seven different European nations for the quantification of histamine in fish muscle. As part of Mandate from the European commission to the European Council for Standardization (CEN), which was signed in December 2010, the optimized, validated method was standardized (Standard EN ISO19343). Three different food types' fish with enzymatic maturation, fish without enzymatic maturation, and fish sauce were used to validate the conventional approach.

Outbreaks of Histamine Fish Poisoning

Wilson [30] examineda 25-year-old woman who resented to the emergency department (ED) with one hour of tongue and face swelling, an erythematous pruritic rash, and dyspnea with wheezing after consuming a tuna sandwich. She developed abdominal pain, diarrhea, and hypotension in the ED requiring admission to the hospital. A diagnosis of histamine fish poisoning was made and the patient was treated supportively and discharged within 24 hours but was readmitted within 3 hours due to an asthma exacerbation. Her course was complicated by recurrent admissions for asthma exacerbations. Rachmawati [24] said that 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 Tongkol (Auxis rochei, 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 the Indonesian 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 is also important, to ensure product safety before consumption.

GC Method

Antoine [1] said, several authors have studied histamine using gas chromatography (GC) as a tool for quantitation, but the methods used were not always suitable depending on the kind of food. Problems frequently cited include incomplete histamine elution from the columns and peak tailing. Histamine is of interest because it is the factor common to all cases of scombroid poisoning, it has physiological and biological activity, and it is a chemical indicator of fish quality. In this study, a modified GC method was used to quantify histamine in mahi-mahi (*Coryphaena hippurus*). Mean recovery was 67% for the GC method, compared with 90% for the AOAC fluorometric method. There was a 0.96 correlation of the GC histamine values with those of the AOAC fluorometric method. A temperature program, splitless /split injection, and analyte clean-up were essential for GC properties.

A gas chromatographic (GC) method, which reduced the time for determination of histamine in fish and fish products to less than 20 min, was demonstrated. Contrary to the traditional GC method, histamine in sample was initially extracted with alkaline methanol and injected into a GC column (CP-SIL 19CB) for analysis without derivatization. The internal standard used in this protocol was 1, 9-nonanedi The detection ion limit for histamine by this method was about 5 mg/g. Standard addition test indicated 98–111% (CV: 2.7–7.8%) of recovery for tuna flesh and 99–102% (CV: 2.7–8.9%) for shrimp meat after adding with authentic compound, suggesting that using direct GC analysis for histamine determination was feasible referred by Hwang et al. (2003).

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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