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Histamine Levels in Fish from Markets in Lima, Perú[†]

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Abstract

Illnesses associated with seafood are an important public health concern worldwide, particularly considering the steady increase in seafood consumption. However, research about the risks associated with seafood products is scarce in developing countries. Histamine fish poisoning is the most common form of fish intoxication caused by seafood and usually presents as an allergic reaction. This condition occurs when fish are not kept appropriately refrigerated and histamine is formed in the tissues. Histamine levels of >500 ppm usually are associated with clinical illness. We assessed histamine levels in fish from markets in Lima, Peru, with a quantitative competitive enzyme-linked immunosorbent assay. Thirty-eight specimens were purchased from wholesale and retail markets: 17 bonito (*Sarda sarda*), 16 mackerel (*Scomber japonicus peruanus*), and 5 mahi-mahi (*Coryphaena hippurus*). Seven fish (18%) had histamine levels of 1 to 10 ppm (three mackerel and four bonito) and three (8%) had >10 ppm (three mackerel, 35 to 86 ppm). Fish from retail markets had detectable histamine levels (>1 ppm) more frequently than did fish bought at wholesale fish markets: 9 (36%) of 25 fish versus 1 (8%) of 13 fish, respectively ($P = 0.063$). Higher histamine levels were correlated with later time of purchase during the day (Spearman's rho = 0.37, $P = 0.024$). Mackerel purchased at retail markets after 2 p.m. had a 75% prevalence of histamine levels of >10 ppm. Mackerel purchased late in the day in retail markets frequently contained high histamine levels, although the overall prevalence of elevated histamine levels was low. Despite the small sample, our findings highlight the need to reinforce seafood safety regulations and quality control in developing countries such as Peru.

Globally, more than 63.5 million tons of seafood are caught and eaten each year (18), representing a steady global increase in seafood consumption (10). However, recent seafood-related disease outbreaks have repeatedly caught the attention of the international press (5, 20). An increase in seafood-related illnesses has been documented (4), and there is now greater interest in seafood safety worldwide.

Histamine fish poisoning (HFP) is probably the most common fish-related intoxication (15). HFP is a medical condition associated with the consumption of scombroid fish (mackerel,

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tuna, bonito, and a few others) (6, 19) and some non-scombroid fish such as mahi-mahi and anchovies (17). The flesh of these fish normally contains histidine. However, prolonged nonrefrigerated storage facilitates histamine synthesis by decarboxylation of histidine via bacterial action (28), leading to increased histamine levels. Histamine is a heat-stable toxin that is tasteless and odorless (17). According to the U.S. Food and Drug Administration (FDA), good quality fish should contain histamine levels less than 10 ppm, and the defect action level is 50 ppm (27). A level higher than 500 ppm of histamine usually causes toxicity, and several reports of generalized allergic-type reactions have been associated with such high histamine levels (11, 13, 16).

HFP has both public health and economic implications (16) and has been described extensively in developed countries, including multiple reports of outbreaks associated with the consumption of raw, cooked, and canned fish (3, 12, 13, 17, 23). In low- and middle-income economies, informal small-scale fisheries, numerous retail markets, and limited government regulations may lead to increased risk. For example, Peruvian regulations do not require systematic monitoring of histamine levels in fish sold in markets (24). Thus, little is known about the epidemiology of HFP in developing countries, particularly regarding the overall risk in regularly consumed fish products. The literature mainly includes descriptions of clinical cases and small outbreaks (2, 7, 26, 29), except for an article published in Chile, in which the authors reported that 6% of foodborne outbreaks were due to HFP (25). After a case of a HFP that occurred as the result of ingestion of bonito later found to have histamine levels of 800 ppm (14), we evaluated the presence of histamine in fish sold in markets in Lima, Peru.

MATERIALS AND METHODS

Fish were acquired from both wholesale fish markets (WFMs) and a convenience sample of retail fish markets (RFMs) in Lima, a city of ~8 million inhabitants. The two WFMs in Lima and 19 geographically dispersed RFMs (Fig. 1) were visited during their usual working hours (WFMs, 4 to 6 a.m.; RFMs, 7 a.m. to 4 p.m.). Only WFMs had overnight −20°C cold storage, but very few sale stands at WFMs and RFMs kept fish in chill boxes or other refrigeration containers during sale hours. The WFMs selected for study are the largest distributors of fish and seafood products in Lima and supply all of the RFMs and most restaurants in Lima.

The study was conducted between April and May 2006 during the austral autumn. Fish were purchased on Monday mornings or early afternoons, usually sampling two markets each day. One of the investigators (V.E.G.) entered the market as a regular customer, purchased each fish sample, and recorded the price, time of day, and GPS coordinates of the market. Three fish species were studied: two scombroid fish, mackerel (*Scomber japonicus peruanus*) and bonito (*Sarda sarda*), and one non-scombroid fish, mahi-mahi (*Coryphaena hippurus*). Whole mackerel and bonito fish specimens were bought, but for mahi-mahi a fillet was obtained from between the pectoral and ventral fin (~250 g). Tuna and anchovies were not sold in any of the markets visited. The price ranges per kilogram were US$1.30 to 1.80, US$0.60 to 1.30, and US$2.50 to 3.80 for bonito, mackerel, and mahi-mahi, respectively. Odor, color, and texture were assessed during purchasing but not systematically recorded. Weight and length were not recorded.

Specimens were put in individual ziplock bags after purchase, placed in a styrofoam container, covered with ice, and transported to the U.S. Naval Medical Research Center Detachment (NMRCD). Samples were either processed immediately upon arrival or frozen for 24 h and processed the next morning. Samples were handled according to the FDA guidelines for testing fish and other marine products (1). Each fish sample was homogenized with a blender, and a 10-g portion was used for testing. The presence of histamine was measured and quantified at the NMRCD using the Veratox for histamine kit (Neogen Corporation, Lansing, MI), a quantitative competitive enzyme-linked immunosorbent assay. This kit quantifies histamine levels in fish from 2.5 to 50 ppm, and higher levels can be detected by diluting samples.

Histamine levels measured as parts per million were analyzed both as a continuous and a dichotomous variable (≤1 ppm versus >1 ppm, and ≤10 ppm versus >10 ppm). We explored the association between histamine presence and market type, fish species, and hour of day. The distance from each RFM to the nearest WFM was calculated in kilometers using the metric tool in ArcMap 8.0 (ESRI, Redlands, CA). Chi-square tests were used to evaluate the association between categorical variables, using the Fisher's exact test when needed. The Spearman's rho correlation coefficient was used to evaluate the association between numeric variables. Data were analyzed with Stata 9.0 (Stata Corp., College Station, TX) and reported with 95% confidence intervals and $P < 0.05$ significance.

RESULTS

A total of 38 fish were sampled: 17 bonito, 16 mackerel, and 5 mahi-mahi. All five mahi-mahi, four mackerel, and four bonito were purchased from WFMs. According to WFM vendors, all bonito and mackerel were caught the previous night and immediately sold within several hours. They also reported that mahi-mahi was preserved frozen at −20°C because the fishing season runs from November to February. This information was compatible with field observations of appearance and odor. The fish eyes were clear, and the flesh texture was firm.

All WFMs and 6 RFMs had permanent infrastructure, and 13 RFMs were street-vendor stands. Nearly all fish in WFMs was sold on beds of crushed ice, whereas at RFMs 62% of bonito specimens (8 of 13) and only 25% of mackerel specimens (3 of 12) were placed on ice beds ($P = 0.075$, Fisher's exact test).

The overall prevalence in fish samples of histamine levels of >1 ppm was 26%, and that for levels of >10 ppm was 8% (Table 1). Three mackerels and four bonitos had histamine levels of 1 to 10 ppm, and three mackerels had levels of >10 ppm (35, 83, and 86 ppm), indicating significant deterioration. All 10 specimens with >1 ppm were from RFMs, except for 1 mackerel with 2.8 ppm that was from a WFM (Table 2). Fish from RFMs had histamine levels of >1 ppm more frequently than did fish from WFMs (Table 1).

All three mackerel specimens with >10 ppm were bought between 2 and 4 p.m. Higher histamine levels correlated with time of purchase later in the day (Spearman's rho = 0.37, $P = 0.024$) but not with price (data not shown). Among the 12 mackerels bought at RFMs, fish purchased after 2 p.m. were more likely to contain histamine at levels >1 ppm (Tables 1 and 2) and the levels were more likely to be >10 ppm (Tables 1 and 2) compared with fish bought before 2 p.m.

DISCUSSION

We found a low (8%) overall prevalence of >10 ppm of histamine in fish, indicating infrequent significant deterioration. All specimens with >10 ppm were from RFMs, where we observed several possible risk factors such as late sale hours, lack of on-site refrigeration, and likely nonrefrigerated transport from WFMs.

Histamine levels higher than 10 ppm were observed in 75% of the mackerel sold after 2 p.m. Mackerel is an affordable, frequently consumed scombroid fish in Peru, and should be a priority for HFP-prevention measures such as sale-hour restrictions and both seller and customer education. In contrast, no bonito presented histamine levels of >10 ppm, probably related to the more frequent use of crushed ice beds in RFM markets where most bonito were sold. No mahi-mahi was found with detectable histamine levels, although our sample size ($n = 5$) prevents us from making a stronger conclusion about the prevalence of high histamine levels in this species. However, mahi-mahi is stored at −20°C in wholesale markets, which may reduce the chances of histamine formation. The pricier mahi-mahi may also require better quality to satisfy more demanding customers.

Histamine levels of 1 to 10 ppm were common in both bonito (24%) and mackerel (19%), and these fish with higher levels were primarily found in RFMs. Although these histamine levels do not represent poor quality fish according to FDA standards (27), they could turn into an actual hazard for consumers depending on transportation and preparation time. HFP could be prevented simply by choosing less risky scombroid or scombroid-like species or avoiding buying mackerel in the afternoon.

Several procedures could be implemented to prevent histamine formation during storage and at the point of sale in RFMs, and some of these already are covered in local regulations (24). Using chill boxes immediately after purchase from WFMs, placing freezers at RFMs, and educating customers about HFP may be useful measures. Alternatively, sales hours could be restricted to mornings only, or temperature control measures could be introduced. These actions probably are less expensive and more practical than mandatory histamine screening. Further evidence is needed to devise appropriate regulations and to assess their impact.

Rapid chilling of fish after catching and adequate handling (22) in WFMs and RFMs are critical for preventing HFP and other illnesses caused by bacterial pathogens. However, these measures will not be effective unless buyers quickly transport fish to their homes and maintain the fish at appropriately cold temperatures until the fish is cooked and eaten (14). For HFP specifically, cooking fish with hazardous histamine levels does not reduce the risk of illness because the toxins that cause HFP poisoning are heat stable (21). Hence, customer behavior is clearly an important link in the transmission chain.

Peru received 2 million tourists during 2007 (8), and gastronomic tourism is blossoming. Seafood is the flagship product of the local cuisine (30), and cebiche, a Peruvian dish prepared with raw fish marinated in lime juice, is frequently consumed by international visitors. However, HFP is probably of little concern for tourists because mackerel is rarely served in seafood restaurants frequented by tourists. High-end seafood restaurants probably maintain better refrigeration than do other types of restaurants. Seasonal seafood restaurants at popular beaches, where appropriate refrigeration may be difficult to maintain, may be a public health risk.

Our study may have underestimated the prevalence of high histamine levels in fish by testing only one portion from each fish because the distribution of histamine in each specimen can vary (17). However, in a previous study in Spain in which only one portion per fish was tested, similar histamine prevalence was found in bonito and mackerel bought in retail markets (19), suggesting that results are probably consistent.

Supermarket chains are a growing phenomenon in Peru and other developing regions throughout the world, but presently they exist mostly in Lima and other capital cities and remain vastly outnumbered by informal markets, both in numbers of stores and percentage of food sales (9). The presence of supermarkets probably has not altered the common habit of buying fresh fish in local retail markets. Thus, enforcement of current regulations is needed to enhance the sanitation of fish sold in public markets, where most people in the developing world still buy fish and marine products. Although the small sample size in this study precludes us from making broader conclusions, the results clearly indicate the need for further research on seafood safety in resource-limited settings.

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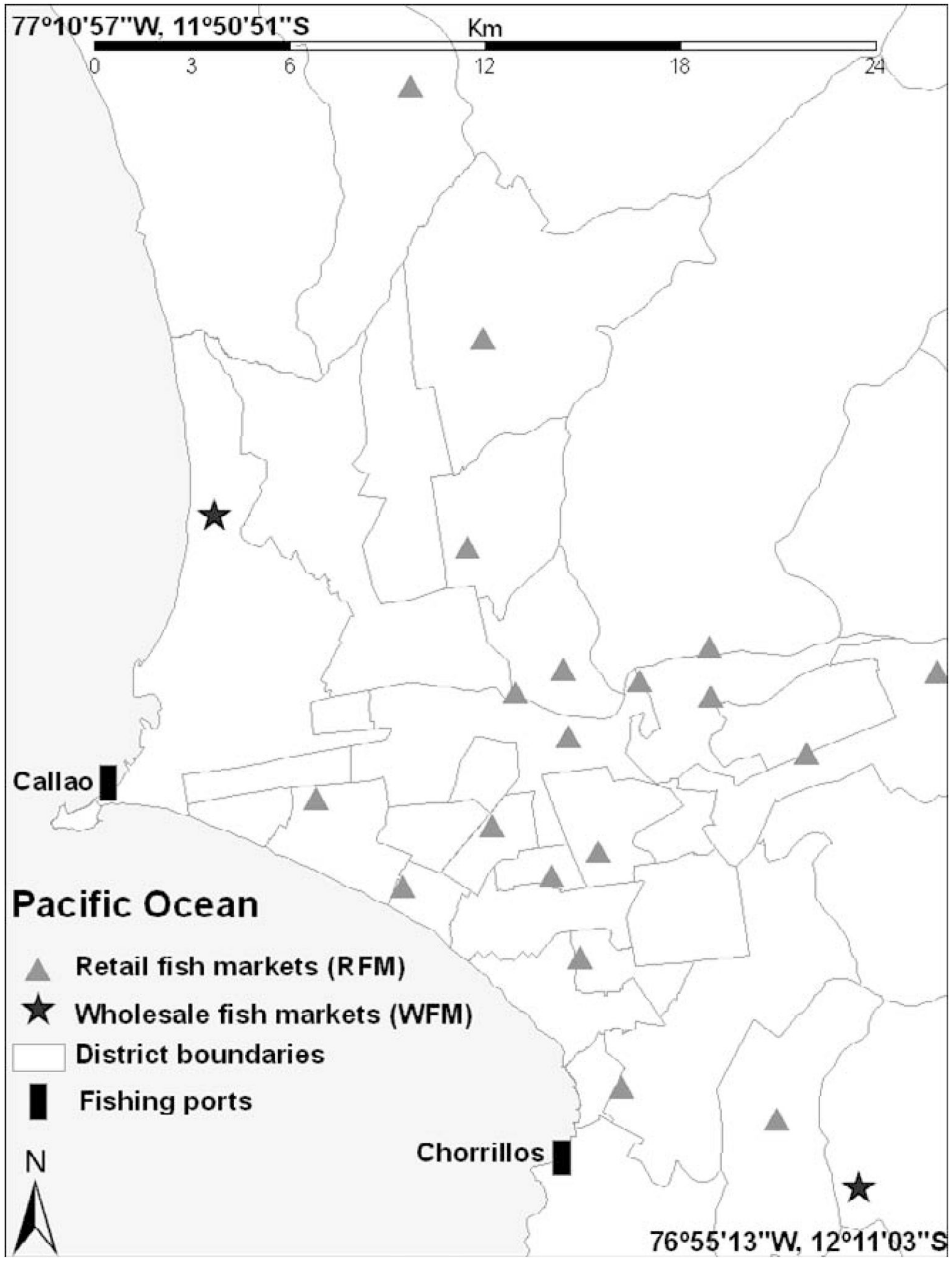

Figure 1.

Location of markets surveyed in Lima, Peru, 2006. The maximum linear distance between RFMs and WFMs is 16 km.

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Table 1

Prevalence of histamine in fish sold in markets in Lima, Peru, 2006

	Histamine, <1 ppm		Histamine, >10 ppm	
Characteristics	**No./total no. (%)**	***P***	**No./total no. (%)**	***P***
Market type				
Wholesale fish market	1/13 (8)	0.063	0/13 (0)	0.273
Retail fish market	9/25 (36)		3/25 (12)	
Fish species				
Bonito	4/17 (24)	0.307	0/17 (0)	0.107
Mackerel	6/16 (38)		3/16 (19)	
Mahi-mahi	0/5 (0)		0/5 (0)	
Time of purchase				
Before 2 p.m.	7/31 (23)	0.257	0/31 (0)	0.004
After 2 p.m.	3/7 (43)		3/7 (43)	
Overall prevalence	10/38 (26)		3/38 (3)	

Table 2

Fish specimens with histamine levels > 1 ppm in Lima, Peru, 2006

Histamine level (ppm)	Market type	Fish species	Purchase time of day
1.5	Retail	Mackerel	7 a.m.
1.7	Retail	Bonito	7 a.m.
2.4	Retail	Bonito	2 p.m.
2.6	Retail	Bonito	11 a.m.
2.8	Wholesale	Mackerel	6 a.m.
5.0	Retail	Mackerel	11 a.m.
6.4	Retail	Bonito	9 a.m.
34.7	Retail	Mackerel	2 p.m.
83.0	Retail	Mackerel	3 p.m.
86.0	Retail	Mackerel	3 p.m.