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Postharvest Handling Practices and the Development of Histamine in Giant Trevally (*Caranx ignobilis)* Fish: The Case of Fiji

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Abstract

The study aimed at assessing the post-harvest handling practices of artisanal spear-gun fishers in Fiji and its impact in the development of histamine. The study employed in-depth interviews of artisanal fishers on their postharvest handling practices, and its relationships in the development of histamine in Giant Trevally (Aranxignobilis) fish. The Giant Trevally fish were further exposed to three different temperatures; 0 °C, combination of 5 °C and 28 °C, and 28 °C prior to histamine determination. Results revealed that spear-gun fishers do not normally ice their fish and rarely gut their catch during the fishing trips. However fish are only iced when received by middlemen and vendors once fish arrive at the landing sites, when stored in the recycled freezer containers. Fish are usually displayed un-gutted without ice on drained and tiled stalls, however used ice at the landing site are further reused to cool fish stored in the recycled freezer containers (above 5 °C) alternatively every 2 h throughout the day for display on the counters (28 °C) for sale. Any unsold fish are returned into the recycled freezer containers for sale the next day. Histamine determination revealed that after 35 h postharvest i.e. further storage at 0 °C and at combination temperatures of 5 °C and 28 °C (recycled every 2 h) the histamine levels went below the Food Drug Administration (FDA) permitted levels (50 ppm). However, fish stored at 28 °C had increased histamine concentration levels up to 193.2 ppm of 15 h post-harvest. The study demonstrated the importance of time and temperature control at postharvest handling of fish in tropical countries.

Keywords: *Histamine, Scombrotoxin, Post-harvest practices*

1. Introduction

Fish is a perishable commodity (Bolta, 1995) and that postharvest handling is crucial in retaining its freshness, quality and safety. Quality parameters of fish are strongly related to its degree of freshness which warrants cold chain along the supply chain. It is understood that from the moment the fish is caught, deterioration process starts (Martinsdottir, 2002) which affects quality. These deterioration processes contribute to changes in the composition and structure of the fish due to biochemical, physical, enzymatic and bacterial reactions which negatively affects the sensory quality of fish and its related products. Good handling practices need to be seriously practiced in order to reduce fish spoilage, wastage and histamine production. Fish handling practices that increase risks of unsafe foods are public concerns which warrant serious action in the prevention of food-borne illness or fish poisoning (Ergönül, 2013) including Histamine Fish Poisoning (HFP).

HFP is a mild food-borne illness mainly caused by decarboxylation of histidine when exposed to high temperature over a long period of time mainly in scombroid fish species such as tuna, skipjack, bonito and mackerel. Some non-scombroid fish including sardines, herring, pilchards, marlin, mahi-mahi, mullet, Kingfish and *Trevally* also have been involved in outbreaks of scombrotoxin. Prevalent in the Asia-Pacific region as well as the United States (Patange *et al.,* 2004), scombrotoxin needs to be monitored and that histamine determination is an important part of food safety and international trade (Björnsdóttir-Butler *et al.*, 2009; Sánchez-Guerrero *et al.,* 1997; Wu *et al.,* 1997). Even though HFP may be common in the Pacific region, cases are rarely reported to medical authorities (WHO, 2011) and not officially recorded. Fish and fish products are regarded as one of the most commonly consumed protein sources in Fiji which showed 66% of the indigenous Fijian households consume fish either once or twice a week (National Food and Nutrition Centre, 2007). Because fish is highly perishable, handling of fish and fish products is crucial in the prevention and reduction of fish poisoning.

While histamine fish illness is associated with high intake of histamine levels greater than or equal to 50 mg/100 g fish (Lehane and Olley, 2000) it should be noted that real toxic dose of histamine to the human body is not easy to determine due to non-homogeneity in the formation of histamine in the fish's body (Lerke *et al.,* 1978) and the presence of other biogenic compounds that potentiate toxicity (Shahidi and

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Simpson, 2004). Generally, the production of histamine in fish is related to various factors such as histidine content of the fish, presence of bacterial histidine decarboxylase (HD), and environmental conditions in which fish is stored (Ienistea, 1973). It is understood that during fish spoilage, certain bacteria produce decarboxylase enzymes, which act on free histidine and other amino acids in the fish muscle to form histamine and other biogenic amines (Eitenmiller and De Souza, 1984). The main bacteria responsible for histidine decarboxylation and HFP are reported to be members of the family *Enterobacteriaceae* (Frank *et al.,* 1985; Taylor and Sumner, 1986). Moreover, studies suggest that storage of longtail tuna at 25 °C for 1 day rapidly increased histamine levels to 284 mg/kg compared to storage at 0 ℃ and 8 ℃ (Abdallah Al-Busaidi *et al.,* 2011).

There are effective testing methods to identify likely toxic fish; hence their control and preventive measures are possible (Shahidi and Simpson, 2004). However, it is not possible to test all fish and thus a Hazard Analysis and Critical Control Points (HACCP) approach is the preferred management approach in the avoidance and reduction of histamine development. The aim of this research was to assess the current handling practices of fish by artisanal fishers and its relationship with histamine development in *Giant Trevally* (*Aranxignobilis*) fish in Fiji.

2. Methodology

This research employed two different approaches; an in-depth interview using piloted questionnaires that gathered the post-harvest handling practices of fish and the determination of histamine in *Giant Trevally* fish that were exposed to three different sets of temperatures.

2.1. In-depth Interview: Post-Harvest Handling Practices

An in-depth interview was conducted on six fishermen and their associated vendors and retailers that identified the supply chain and the associated handling practices of fish they caught, handled and/or processed and auctioned. The handling practices data related to time and temperature were used to set up a time-temperature abuse pilot experiment to demonstrate the relationship between time-temperature exposure discussed below and the development of histamine in *Giant Trevally* prior to histamine determination.

2.2. Histamine Determination

2.2.1. Sample Preparation

A batch of *Giant Trevally* containing a total of 5 fish was purchased from the major local fish market in the Capital City; Nabukalou Creek, Suva. The history and temperature of the batch of fish that was purchased was gathered through in-depth interview discussed above prior to transportation of fish to the postharvest laboratory at the University of the South Pacific. In the lab, the fish were quickly cleaned, filleted and diced into 1 cm cubes and stored at three different sets of temperatures; 0 °C, 28 °C and temperature combination of 5 °C and 28 °C respectively for up to 35 h in total, prior to histamine determination using the Histamine Test Kit purchased from AltiMed Australia Pty Ltd discussed below.

2.2.2. Histamine Determination

In brief, approximately 3 g of *Giant Trevally* fish tissue was homogenized of which 1 g was transferred to a heat resistant test tube and added with 24 mL of EDTA buffer, boiled for 20 min and cooled to <20 °C with use of ice prior to filtration in which the liquid phase was used for histamine analysis. Absorbance was measured at 470 nm with the UV Spectrophotometer Brand Kyoritsu Chemical; Corporation, Model ABS-B470.

3. Results and Discussion

Hygiene and good handling practices along the supply chain; from on board the fishing vessel, at the landing site, during transportation and processing of fish remain the highest priority in avoiding contamination and cross-contamination which help in the reduction of histamine levels in fish species high in histidine.

3.1. Post-Harvest Handling Practices

Figure 1 shows the current postharvest handling practices of fish caught by artisanal fishermen through spear-gun method that are auctioned or sold by their associated vendors or retailers. In-depth interviews revealed that most artisanal fishermen go out fishing overnight; usually from 7 p.m. (after the sunsets) and return home around 7 a.m. (before the sunrises). This means that approximately a total of 12 h of fishing trip is under taken by artisanal fishers that usually use the small size on-board vessels (23 feet by 6 feet) and that they do not use ice. According to these fishers, the 12 h overnight fishing trip is a short fishing duration hence there is no need to use ice for chilling their catch. Fish in this case are usually stored loose on the pallets on-board the vessel overnight without ice. Because these fishers know exactly the site where there is higher fish stock and the best time to catch them reduced their duration of fishing trip. Hence spear-gun fishers prefer to catch fish when the fish are asleep between 10 p.m. to 5 a.m. This takes approximately 6-7 h of catching fish depending on weather conditions and the species of fish available.

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Fishers usually sort their catch by size and are threaded in bundles without gutting before they are placed back on loose pallets without ice for storage. The fish are then transported to the fish landing sites in Suva, in time for the arrival of middle-men and retailers/vendors around 7 a.m.

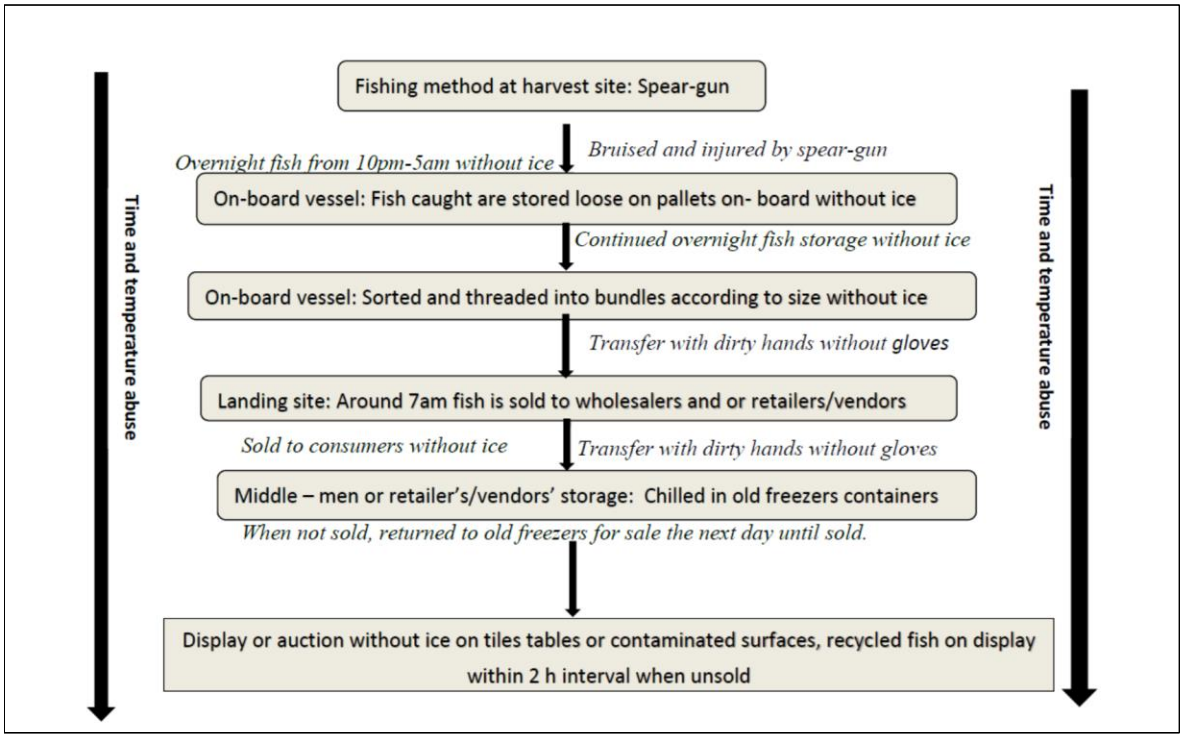

Figure 1. Post-harvest handling practices of fish from harvest to auction/sale.

At the landing sites, the bundled fish are handled and transferred by middle-men, retailers or vendors without gloves from the fishing vessels into the recycled freezers containers containing ice. This may reveal that the icing or chilling of fish only takes place upon landing. A random test of the temperature of fish iced in the esky range 5-13 °C and fish displayed on the counter revealed insufficient temperature control at 18 °C and 28 °C which demonstrated insufficient use of ice. The ratio of ice to fish appear not to match and this may be one of the reasons in the increase in the rate of ice melting without continuous replacement of new ice. Likewise, four display counter sites with fish were randomly tested with fish temperature which revealed the average temperature of 28.5 °C that may demonstrate temperature abuse and breaking the cold chain along the supply chain by middlemen. Low proportion amount of ice is used with respect to the amount of fish may be due to high cost of ice sold by ice manufacturers.

Furthermore, most recycled freezer containers look unhygienic and do not have drain-holes that should allow melted-water to drain away. This may have contributed to accumulation of drip from fish that are tainted with blood providing good source of nutrients for bacterial growth. When auctioned, some fish are displayed on tiled and well drained stalls un-gutted and without ice, which sometimes are kept for hours before being sold. Majority of the fish vendors recycled the fish on display by putting the fish back in the recycled old freezer containers every 2 h, together with the melted-water. Any unsold fish for the day are returned into the old recycled freezer container for sale the next day. It has been observed that melted-water is not usually removed from the old freezer containers. This appears to be a common practice by the vendors. Instead, new ice is simply added onto the fish containing melted- water mixture. This practice of recycling of fish at the combination temperatures of 5 °C and 28 °C every 2 h was adopted as part of the experiment discussed below prior to the determination of histamine. The major issues identified in the current post-harvest practices with fishermen include:

- The inappropriate fishing method used for catching fish. These spear-gun fishers use sharp gear causing open injury and bruises to fish that contributed to acceleration of deterioration and spoilage of fish. The impact of such fishing method becomes more

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complex during long fishing trips especially when ice is not used or not sufficient use of ice.

- Fish are openly exposed on pallets on-board fishing vessels without proper cool storage or ice. The problem is aggravated when the fishing vessels are un-hygienically dirty without proper cleaning and sanitize prior to the fishing trip.
- Chilling of fish in dirty old recycled freezer containers with melting ice, and addition of new ice without removing melting water which increase chances of fish contamination.
- Displaying of fish for auction or sale without ice and recycling the fish every 2 h intervals back into the old dirty melted ice when not sold. Any unsold fish are returned into the old recycled freezer containers for sale the next day further increase chances of contamination and recontamination.

3.2. Histamine Determination

Histamine is considered to be the principal toxic component of scombrotoxin, although other compounds such as biogenic amines including putrescine and cadaverine may also play a role in scombrotoxin ("Histamine -Scombrotoxin", n.d.). Food regulations in most countries allow counts up to 50 or 100 ppm, as safe levels (FDA, 1998). In countries with small coastal vessels, a lack of supply of ice and insufficient cold supply chain with poor hygienic circumstances, histamine is unfortunately still frequently detected at high levels. Acceleration of histamine development to unacceptable levels takes place when fish is transported in un-chilled trucks or open air in tropical temperatures ("Histamine-Scombrotoxin", n.d.).

Figure 2 shows the histamine level of *Giant Trevally* that were further exposed to three different temperatures; 0 °C, 28 °C and combination of 5 °C and 28 °C after 35 h of post-harvest exposure. The three temperatures selected was based on the information gathered from the in-depth interview discussed in section 3.1 in which recycling of fish at auction or display of fish for sale occurs between 5 °C and 28 °C at intervals of 2 h. Results revealed that *Giant Trevally* stored at 28 °C only, had elevated growth of histamine levels over 15 h post-harvest compared to 0 °C only, and combination temperatures between 5 °C and 28 °C recycled fish. The results obtained in this study confirmed that low temperature; 0 °C and 5 °C are effective in controlling, limiting and suppressing histamine formation that had been supported by several studies (Guizani *et al.*, 2004; Silva *et al.*, 1998). This confirmed negligible levels of histamine detected at storage temperature of 0 °C and below. This means that histamine development is suppressed during storage at such low temperatures. Further results at 28 °C only, revealed the highest concentration of histamine at 193.16 ppm after 15 h of exposure. This data appears to be in agreement with Mu¨ ller *et al.* (1992) and Arnold *et al.* (1980) that reported the highest histamine level detected in *Trevally* species stored at 28 °C was detected unacceptable highest histamine concentration after two days of storage. This may be due to the optimal temperature for most bacteria that grow at 20-30 °C, although some histamine producing bacteria such *vibrio* species have temperature optima below 10 °C (McMeekin *et al.*, 1993). It is interesting to observe that histamine level at 28 °C exposure only, exceeded the FDA permitted levels of 50 ppm fresh weight at 13.5 h post-harvest and exceeded the EU permitted levels of 100 ppm fresh weight at 14.0 h post-harvest duration.

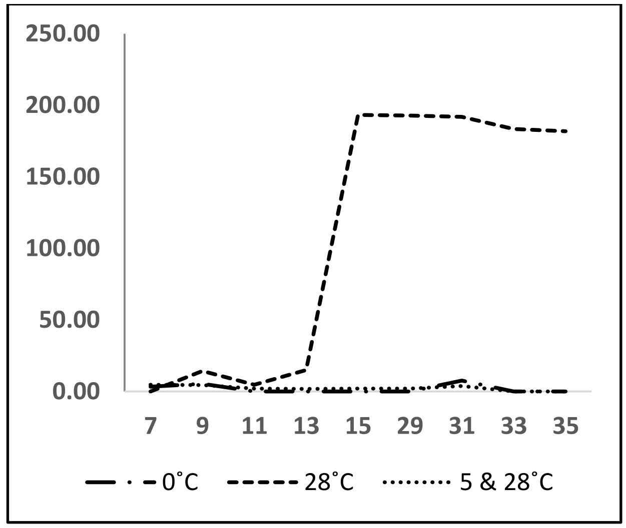

Figure 2. Histamine levels (ppm) of *Giant Trevally* stored at 0 °C, 28 °C and combination between 5 °C & 28 °C.

According to Brinker *et al.* (2002), histamine level in a composite sample of fish or fish products, other than crustaceans or molluscs, must not exceed 100 mg/kg. If histamine levels are above 100 mg/kg it may indicate that fish had been mishandled during storage and processing. Moreover, histamine-forming bacteria are capable of growing and producing histamine over a wide temperature range, however more rapid at high-abuse temperatures of 21.1 °C and higher than moderate-abuse temperatures of 7.2 °C (Emborg *et al.*, 2004). It has been argued that histamine growth is particularly rapid at temperatures near 32.2 °C (FDA, 2011). It has been observed that histamine is the result of high temperature spoilage for long-term, while relatively low-temperature spoilage is commonly associated with organoleptically detectable decomposition (FDA, 2011). Handling fish at high temperatures such as 20 °C contributes towards spoilage of fish with regards to histamine level mainly in the subtropical countries. Emborg *et al*. (2004) argued that

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formation of microbes on histamine and biogenic amines in chilled fresh tuna stored at 2 °C vacuum-packed (VP) cause histamine poisoning at a concentration of >7000 mg/kg. Histamine ELISA kit and plate count agar (Auerswald *et al.*, 2005) have proven histamine to be strongly dependent on temperature-time (Yesudhason, 2013).

Interestingly this study of *Giant Trevally* samples stored at the combination temperatures between 5 °C and 28 °C recycled every 2 h showed histamine levels well below FDA and European Union (EU) permitted levels. The highest recording was 4.8 ppm at 7 h of storage. This result appears to be in agreement with that of Lopez-Sabater *et al.* (1996) who observed the growth of histamine stopped in bigeye tuna when it reached its maximum level. Similarly, Sato *et al.* (1994) also observed that initially, histamine accumulated in fish stored at 5 °C and then levels start decreasing when the count of histamine decomposing bacteria exceeded 10^6 cells/g. These results are comparable with the study conducted by Auerswald *et al.* (2005), who reported that histamine level in the *Trevally* sample stored at 5 °C only (Sato *et al.*, 1994) increased only marginally from 1.7 to 5.3 ppm during four days. However, because the current research was only conducted for duration of 35 h post-harvest observation, data could not be matched. Nonetheless, one could predict that combination temperatures of 5 °C and 28 °C could help delay the formation of histamine below FDA permitted levels to a certain degree only for a short duration and expected to increase during long storage. The result of this study confirmed that temperature and time control are essential in the prevention of histamine development. There may be other factors that contribute to the rate of histamine growth at certain temperatures including species which may be due to biological make-up (Kanki *et al*., 2004) and as well as normal microbial flora on fish and post-catching contamination on board fishing vessels. The key to keeping bacterial numbers and histamine levels low is the rapid cooling of fish after catching and the maintenance of adequate refrigeration during handling and storage as observed at 0 °C which delayed spoilage.

Although many countries have set guidelines for maximum permitted levels of histamine in fish including EU and FDA at 50 ppm and 100 ppm respectively (FDA, 1998), histamine concentrations within a spoiled fish are extremely variable, as in the threshold toxic dose. Despite the huge expansion in trade in recent years, great progress has been made in ensuring the quality and safety of fish products mainly through the introduction of international standards of food hygiene and the application of risk analysis and hazard analysis and critical control point (HACCP) principles (Huss *et al.*, 2004). These safety standards and HACCP need to be strengthened and implemented in Fiji fisheries department in order to reduce and avoid scombrotoxicity.

4. Conclusion

The current handling practices of scombroid fish when recycled at 2 h interval between 5 °C and 28 °C up to 35 h of post-harvest appeared to have safe levels of histamine. However, continuous recycle at 28 °C only, after 13 h of post-harvest of scombroid fish revealed unsafe levels of histamine, contributing to unnecessary levels of histamine poisoning. Further investigation of histamine development in fish exposed to 2 h interval and recycled between 5 °C and 28 °C beyond 35 h post-harvest especially when fish are not sold after 3-4 days.

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