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# Scombrotoxins, part 2

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## Prevalence in seafood

Amberjack and other scombroid fish can potentially cause scombroid poisoning. Amberjack broodstock photo from the University of Miami Florida Keys Rosenstiel School of Marine and Atmospheric Science, courtesy of NOAA.

Biogenic amines from fish and shellfish are among the foremost causes of seafood-related morbidity worldwide. Seafood harvesters and processors should be keenly aware of the conditions that exacerbate the formation of these compounds in their products, the tendency of different areas of a fish carcass to support formation of these amines, and the effects of bacterial flora on the formation of these toxins.

## Biogenic amines in fish

The prevalence of biogenic amines in fish depends on several factors. In general, concentrations in newly caught fish are low. For example, research found cadaverine values ranged 1.16 to 10.36 ppm in high-quality rockfish, salmon steaks, and shrimp, and putrescine levels ranged 1.36 to 6.30 ppm in high-quality lobster tails, salmon steaks, and shrimp. Another study reported that high-quality tuna had cadaverine and putrescine values ranging 0.24 to 5.32 and 0 to 1.84 ppm, respectively.

Biogenic amine prevalence also varies year to year. For example, a three-year study focused on biogenic amines in 102 samples of albacore tuna harvested off the northwest U.S. coast from 1994 to 1996. There were significant differences of amine levels in these fish depending on the year.

Total levels of spermine, spermidine, putrescine, cadaverine, histamine, and tyramine varied 5.9 to 56.5 ppm. These levels were probably lower due to the fact that the samples were frozen on board or chilled on board and immediately frozen after reaching the dock and kept at minus-40 degrees-C until analysis. Spermine was present at higher levels, followed by spermidine, histamine, putrescine, cadaverine, and tyramine.

## Muscle type

Researchers have observed no difference in amine levels in upper and lower loin light muscles. However, dark muscles contained higher concentrations of spermidine (Table 1). Samples from intestine walls contained high amine levels.

One particularly broad study examined the amounts of histidine and histamine formed in 21 aquatic species during spoilage. The conclusions were consistent with those of other researchers: more histamine is produced in the red muscle fishes, such as tuna and mackerel, than in white muscle species such as rockfish.

**Table 1. Levels of biogenic amines in varied tissues of albacore tuna. Source: Gloria et al., 1999**

| Samples | Spermine | Spermidine | Histamine | Putrescine | Cadaverine | Serotonin | Total |
|---|---|---|---|---|---|---|---|
| Light muscle upper loin | $0.68 \pm 0.12^{b}$ | $0.26 \pm 0.07^{c}$ | $0.00^{b}$ | $0.22 \pm 0.07^{ab}$ | $0.13 \pm 0.02^{b}$ | $0.00^{b}$ | $1.29 \pm 0.17^{c}$ |
| Light muscle lower loin | $1.21 \pm 0.26^{b}$ | $0.25 \pm 0.05^{c}$ | $0.00^{b}$ | $0.14 \pm 0.05^{b}$ | $0.11 \pm 0.06^{b}$ | $0.00^{b}$ | $1.77 \pm 0.37^{c}$ |
| Dark muscle | $2.50 \pm 0.97^{ab}$ | $0.79 \pm 01.8^{b}$ | $0.00^{b}$ | $0.06 \pm 0.03^{b}$ | $0.07 \pm 0.05^{b}$ | $0.00^{b}$ | $3.42 \pm 0.72^{b}$ |
| Intestine wall | $5.35 \pm 2.46^{a}$ | $3.63 \pm 1.18^{a}$ | $0.52 \pm 0.25^{a}$ | $0.43 \pm 0.16^{a}$ | $1.96 \pm 0.59^{a}$ | $4.38 \pm 1.33^{a}$ | $16.3 \pm 4.59^{a}$ |

## Microflora

A variety of microorganisms is able to produce biogenic amines. The production of cadaverine and putrescine is not surprising, since studies have shown that the covalent linking of cadaverine and putrescine to peptidoglycan is necessary for normal microbial growth. As such, production of these amines supports the continued expansion of microbial colonies on the surface of fish.

Several inoculation studies on both culture media and fish have shown that the microorganisms *Morganella* sp., *Proteus morganii, Proteus* sp., *Hafnia alvei,* and *Klebsiella* sp. can produce histamines and other biogenic amines. The majority of the studies also concurred that the potential of these microorganisms to produce toxic levels of biogenic amines is potentiated at abusive temperatures.

Tables 2 and 3, which summarize research on biogenic amines, show study results on the production of biogenic amines by bacterial isolates inoculated on different culture media and fish likely to be cold smoked, respectively. In addition, data from studies where isolates from fish were incubated and histamine production monitored are shown in Table 4.

**Table 2. Production of biogenic amine by bacteria growing on media culture.**

| Histamine Producer | Histamine Concentration | Temperature and Time |
|---|---|---|
| *Morganella* sp. | 1,000 ppm<br>1,000 ppm<br><br>0 ppm | 5° C for 24 hours<br>25° C for 19 hours, followed by 5° C for 100 hours<br>5° C for 100 hours |
| *Proteus* sp. | large | |
| *Proteus morganii* | More than 200 nM/ml | 15, 30, 37° C for less than 24 hours |
| *Enterobacter aerogenes* | More than 200 nM/ml | |
| *Klebiella pneumoniae* | large | 15, 30, 37° C for less than 24 hours |
| *Hafnia alvei* | large | 30, 37° C for more than 48 hours |
| *Citrobacter freundii* | large | 30, 37° C for more than 48 hours |
| *Escherichia coli* | large | 30, 37° C for more than 48 hours |

**Table 3. Production of biogenic amines by bacteria isolates incubated on fish.**

| Bacteria | Fish | Histamine (ppm) | Other Biogenic Amines | Temp. |
|---|---|---|---|---|
| *Proteus morganii* | Tuna | More than 50 ppm<br>Less than 50 ppm | | 24, 30° C<br>15° C |
| *Acinobacter* | Spanish mackerel | | More than 1ppm | 0° C |
| *Aeromonas hydrophila* | Spanish mackerel | | More than 1ppm | 0° C |
| *Clostridium perfringens* | Spanish mackerel | | More than 1ppm | 0° C |
| *Enterobacter aerogenes*<br>*Enterobacter* sp. | Spanish mackerel<br>Mackerel | <br>detectable | More than 1ppm<br>detectable | 0° C |
| *Hafnei alvei* | Spanish mackerel | | More than 1ppm | 0° C |
| *Morganella morganii* | Spanish mackerel | | More than 1ppm | 0° C |
| *Proteus* sp.<br>*Proteus vulgeris*<br>*Proteus mirabilis* | Spanish mackerel | | More than 1ppm | 0° C |
| *Pseudo-monas sp.* | Spanish mackerel | | More than 1ppm | 0° C |
| *Vibrio alginolyticus* | | | More than 1ppm | 0° C |

**Table 4. Production of biogenic amines on culture media by microorganisms isolated from fish.**

| Microorganism | Fish | Histamine | Temperature and Time |
|---|---|---|---|
| *Proteus morganii* | Skipjack<br>Jack mackerel<br>Sardine | More than 1,000 ppm | 35° C for 24 hours |
| *Proteus* sp. | Skipjack<br>Jack Mackerel<br>Sardine | More than 1,000 ppm | 35° C for 24 hours |
| *Morganella morganii* | Tuna | More than 1,000 ppm<br>More than 1,000 ppm<br>More than 1,000 ppm | 37° C for 18 hours<br>7, 19, 30° C for 24 hours<br>15, 25° C |
| *Klebsiella* sp. | Tuna | More than 1,000 ppm | 37° C for 18 hours |
| *Enterobacter aerogenes* and *E. cloacae* | Tuna | 500-1000 ppm | 37° C for 18 hours |
| *Citrobacter freundii* | Tuna | Less than 250 ppm | 37° C for 18 hours |
| *Proteus mirabilis* | Tuna | Less than 250 ppm | 37° C for 18 hours |
| *Proteus vulgaris* | Tuna<br>Sardine | Less than 250 ppm<br>Less than 1,000 ppm<br>100-2,000 ppm | 37° C for 18 hours<br>7, 19, 30° C for 24 hours<br>35° C for 24 hours |
| *E. agglomerans* | Tuna | Less than 250 ppm | 37° C for 18 hours |
| *Serratia liquifaciens* | Tuna | Less than 250 ppm | 37° C for 18 hours |
| *Providencia stuarti* | Sardine | 150-1,000 ppm | 35° C for 24 hours |
| *Vibrio* sp. | Sardine | 100 ppm | 35° C for 24 hours |
| *Stenotrophonas maltophilia* | Tuna | 25.8 ppm<br>More than 1,000 of other biogenic amines | 4° C for 6 days<br>37° C for 24 hours |

Similarly, when the relationship between microflora on horse mackerel and dominant spoilage bacteria was investigated, results showed that *Pseudomonas I/II, Pseudomonas III/IV-NH, Vibrio,* and *Photobacterium* were dominant when high levels of putrescine, cadaverine, and histamine were detected.

The activity of decarboxylase enzymes produced by bacteria can be an indirect measurement of potential for biogenic amine formation. A study showed that 14 bacterial isolates from mackerel tissue were capable of exhibiting decarboxylase activity (production of histamine, cadaverine, and putrescine) when incubated in Spanish mackerel at 0, 15 and 30 degrees-C. Many other bacteria also have strong histidine decarboxylase activities.

## Best practices required

Since many microorganisms can cause scombrotoxin illness, it is imperative that fishermen, processors, distributors and retailers employ high-level sanitary practices for products under their control. The production of histamine and other biogenic amines can be effectively controlled by cooling fish as quickly as possible after harvest, maintaining fish temperatures constantly under 4 degrees-C, and implementing effective sanitation programs at processing and distribution facilities. Scombrotoxin poisoning can easily be avoided through adherence to good manufacturing practices from harvest through sale to consumers.

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