Bacterial, chemical residues impact tilapia quality

1 January 2008 George J. Flick, Jr., Ph.D.

Arsenic, other metals pose potential health risks

Although tilapia are an increasingly popular fish, they are still subject to food safety and product quality issues.

The microbial and chemical contents of foods involved in international commerce have recently received increased attention. Rapid industrialization combined with natural conditions in certain geographic areas have resulted in tilapia and other fish species becoming contaminated with biological agents and chemical compounds.

Imports are being increasingly tested for quality and safety by regulatory agencies and customers. Producers that do not employ appropriate quality assurance programs may have their products rejected for noncompliance. The penalties for noncompliance can range from temporary detention of products for testing to a total ban on importation.

Bacterial impacts

In a 2005 study, the microbiological flora in both brackish pond water and fish were determined at three different locations to identify microorganisms that could be pathogenic to the fish and also affect their storage life and quality (Table 1).

Flick, Bacteria measured in pond water, Table 1

Sample Source	Microbial Population Ranges
Pond Water (cfu/ml)	1.5×10^3-8.6×10^3
Sediment (cfu/g)	3.1×10^6-1.1×10^7
Gills (cfu/g)	1.9×10^5-0.9×10^6
Intestine (cfu/g)	2.4×10^7-1.6×10^8

Table 1. Bacteria measured in pond water, sediment, and tilapia.

In total, 19 bacterial species were identified, predominantly in the form of Gram-negative rods. In all the populations, the predominant bacterial species with prevalence of over 10 percent were *Vibrio parahaemolyticus*, *V. carchariae*, *V. alginolyticus*, *Chryseomonas* species, *V. vulnificus*, and *Streptococcus* species. The sediment population was an exception, where *Streptococcus* was replaced by *Shewanella putrefaciens.*

At 58 percent of the total isolates, vibrios dominated the total bacterial population. Other identified bacteria included *Aeromonas hydrophila*, *Bacillus* and *Burkholderia* species, *Pasteurella pneumotropica*, *Photobacterium* and *Pseudomonas* species, *Serratia liquefaciens*, *Staphylococcus* species, *V. cholerae*, *V. fluvialis*, and *V. furnissii*.

Gill diseases may be initiated by opportunistic bacteria already resident on animals' gill surfaces. *Streptococcus* bacteria pose the most serious disease threat to the tilapia industry. Moreover, these bacteria have been known to pass from fish to humans who handled them.

If a disease outbreak occurs in a production system, *Vibrio* species proliferate, thereby increasing the possibility that all fish will be infected. The high incidence of vibrios in ponds and on fish can create a problem if the culture water for tilapia is subsequently used to grow another aquatic species. Shrimp and marine fish such as sea bream, sea bass, and turbot are susceptible to vibriosis disease.

Human effects

V. parahaemolyticus is a common foodborne disease pathogen of aquatic origin in which infections have been related to the consumption of farmed finfish. However, the bacteria are more closely associated with the culture of oysters and other mollusks.

A new biotype of V. vulnificus caused hundreds of serious infections among persons who handled live tilapia produced in Israel. Infections by this bacterium are serious in immunocompromised individuals – mortalities can approach 48 percent.

Aeromonas hydrophila is an opportunistic pathogen for individuals whose health has been previously compromised. Certain *Streptococcus* infections have occurred in individuals who worked in recirculating aquaculture facilities. These bacteria can be serious, since many have become highly resistant to both traditional and new antibiotics.

Product quality

While some bacteria are pathogenic to aquacultured animals and humans, others could have an impact on product quality and safety. Some strains of *Shewanella putrefaciens*, for example, are capable of producing strong and offensive off-odors or flavors, which result in consumer rejection of the product. This is somewhat analogous to the earthy or muddy off-flavor or odor problem caused by the presence of compounds such as geosmin or methylisoborneol.

During processing operations, bacteria from the intestines, gills, and surfaces of fish are commonly transferred to processed products, regardless of the level of automation used in the processing operation. Pseudomonas is a facultative group of bacteria that results in food spoilage even if the product is stored at temperatures below 2 degrees-C.

Chemical impacts

Arsenic contamination of groundwater is a major environmental concern in some countries. High arsenic concentrations in well water have been associated with blackfoot disease and other human illnesses. In some areas, arsenic concentrations top 0.30 ± 0.35 mg per liter in 95 percent of the well water, far exceeding the World Health Organization guideline of 0.01 mg per liter. While much of the well water containing arsenic is not directly ingested by most inhabitants in the problem regions, it is still used extensively in aquaculture.

Tilapia, like many fish species, accumulate arsenic in their tissues. The inorganic arsenic concentrations in farmed fish increase as the arsenic concentration of pond water increases, causing a potential cancer risk for fish and consumers alike. Decreased survival and reproductive ability observed in the fish were related to the accumulation of metals in the aquatic organisms.

Pond water taken from certain rivers may also be significantly contaminated with polycyclic aromatic hydrocarbons (PAHs), dichloro-diphenyl-trichloroethane (DDT), and three toxic metals; cadmium, chromium, and lead. Tilapia grown in waters contaminated with these chemicals ormetals could present a health risk to consumers.

The results of a 2005 study of chemical contamination in tilapia fillets showed that total PAHs ranged 15.1-92.5 ng per gram. There is no U.S. standard for the presence of this pollutant. Total DDTs ranged 0.53-31.70 ng per gram, which exceeded the 14.40 ng per gram concentration permitted by the United States Environmental Protection Agency. If the maximum tolerable intake level for DDTs is considered, the amount of fish that can be safely consumed is less than a typical serving size. Concentrations for the three metals and allowable levels are contained in Table 2.

Flick, Cadmium, chromium, and lead, Table 2

Chemical	Concentration (ng/g)	Allowable Concentration (ng/g)	Location
Cadmium	< 0.01-298.00	100[1]	Europe
Cadmium	< 0.01-298.00	200[2]	Australia, New Zealand
Cadmium	< 0.01-298.00	2,000[3]	Hong Kong
Chromium	< 0.01-884.00	500[4]	China
Chromium	< 0.01-884.00	1,000[3]	Hong Kong
Lead	507.00-3,519.00	400[1]	Europe
Lead	507.00-3,519.00	500[2]	Australia, New Zealand
Lead	507.00-3,519.00	6,000[4]	Hong Kong

Table 1. Cadmium, chromium, and lead in tilapia grown in different geographic regions.

Depending on the amount of fish consumed by a specific population, fish containing elevated levels of these three metals could present a health hazard. Ponds containing the greatest amount of the organic and inorganic pollutants were most often found in geographic regions experiencing rapid socioeconomic growth.

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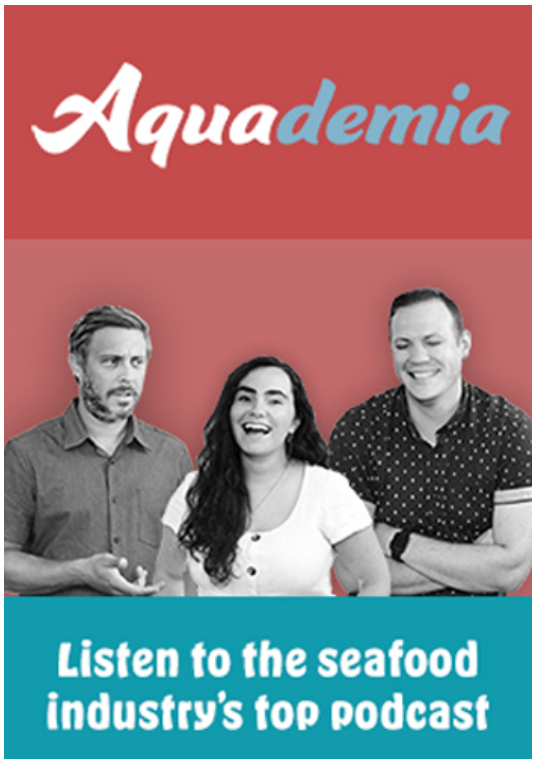

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