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Intelligence

Food safety, quality control in tilapia products

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A look at antibiotics, carbon monoxide and potential contaminants

Tilapia have rapidly increased in popularity on a worldwide basis, in part because the health and safety risks associated with the production and consumption of the species are minimal. Environmental groups as well as the general public have also recognized the fish as one of the "greenest" aquaculture products. Tilapia feed on a low trophic level and require little if any fishmeal or fish oil in feed. Due to tilapia's overall hardiness, very few drugs or chemicals are used in normal production.

For tilapia, the most important quality issue is off-flavor in fish that have been exposed to the organic compounds geosmin or methylisoborneol during production. Safety issues are of lesser concern, but include the potential for hormone residues from sex reversal, the possibility of antibiotic residues, concerns over the use of carbon monoxide or liquid smoke as a preservative and color enhancer in frozen fillets, and the general potential for contamination during production or processing. Scientists, government regulators, farmers, and processors have developed a number of strategies to address these concerns and strive to provide steadily improving products to consumers.

The “green” nature of tilapia has combined with their minimal health and safety issues to make the species a growing worldwide favorite.

Off-flavors

For processors and consumers, by far the main quality issue for tilapia is the presence of off flavor compounds that derive primarily from cyanobacteria (blue-green algae) and less frequently from actinomycetes. The problem is the presence of geosmin and methylisoborneol (MIB), organic chemicals produced by blue-greens and actinomycetes that accumulate in the flesh of tilapia. The fish ingest the organisms while grazing or filter feeding, or concentrate the compounds directly from the water column, as the cyanobacteria and actinomycetes can releaseMIB and geosmin extra cellularly.

Expensive analytical chemistry methods can test for MIB and geosmin, but the practical method is to fillet a couple of fish from the growing unit before harvest. The fillets are placed in a brown paper bag and cooked for 30 to 60 seconds in a microwave. Even an untrained person can easily detect the bad odor when the bag is opened if there is any significant amount of geosmin or MIB present. Most people can detect these compounds at 5 to 10 ppb levels, so even minor traces must be removed.

Luckily, these compounds are quite volatile and degrade quickly. Just two or three days of placing the fish in clean water without the causative organisms purge the compounds. Depuration systems have become fairly common in vertically integrated Latin American farms, whose product is bound primarily for North American fresh fillet markets.

In Asia, processors are making uneven efforts to test fish at farms and work with farmers to depurate fish.More commonly, product identified as off-flavor at processing plants is considered lower grade and sold into domestic markets rather than international trade. However, it is not uncommon to find off-flavor frozen tilapia fillets.

Improved quality control from farms to processing plants and greater use of depuration facilities are critical, especially for Asian producers. Off-flavors are most common in pond production systems, but can occur in virtually any type of rearing facility, including intensive recirculating systems, which often have populations of actinomycetes and cyanobacteria attached to tank surfaces and inside piping.

Hormones

A technological advance that sped the advance of tilapia production on a global basis was the use of methyltestosterone (M.T.) in feed for the sex reversal of fry. Male tilapia grow faster than females and to a much larger average size. The standard dosage for M.T. is 60 mg/kg of feed given to fry during their first 21 days of feeding. This small amount is sufficient to induce the undifferentiated gonads of the female fry to develop as testes and for the fish to become morphological males.

This practice has been approved for use in food fish in countries around the world. Various authors demonstrated that, when used properly, the hormone is metabolized below detectable levels in the fish in a matter of days or weeks, and months before fish are harvested for food. However, some retailers and consumers reject the use of any hormone at any stage in the production of their food. Also, accidental application of hormone-treated feed before harvest is conceivable. Several strategies have been implemented by the tilapia industry to address these concerns.

First, some growers simply rear untreated fish with a natural mixed-sex population. With the recent advances in selective-breeding programs that result in larger males and females, this is becoming an increasingly popular option. Others rear hybrids of *Oreochromis niloticus* x *O*. aureus that naturally have a sex ratio skewed toward males. In both cases, costs are higher, so the prices to consumers are raised.

Another strategy is to produce male broodfish with two Y chromosomes. These brood males, produced through treatment of parent fish with estrogen and then progeny testing to determine which are the 25 percent YY, result from the cross of a normal male with a sex-reversed, male-to-female fish. The progeny of a YY male with a normal XX female are essentially all XY fry or genetically male tilapia.

Second, in cases where M.T. is used, several practical safeguards are instituted. The manufacture of sex-reversal diets can be centralized so only one location has the M.T. and produces the fry food. Most farms also separate the hatchery, where fry feed is used, from the rest of the farm operation. In further segregation, growout diets are almost always large, pelleted feeds stored in cool, dry feed bins, while M.T.-treated fry feed is a powder that must be stored in coolers or freezers.

Processors as well as farmers have developed effective strategies to provide steadily improving tilapia products for consumers.

Antibiotics

Tilapia are extremely hardy fish that are rarely impacted by disease outbreaks. The use of antibiotics has therefore been historically limited. However, as tilapia farms became more intensive and fish were stressed at higher densities, bacteria genera such as *Streptococcus*, *Flavobacterium, Aeromonas* and *Edwardsiella* were reported. The bacteria have caused significant losses, especially in smaller fish, but the overall effects have not significantly affected production levels.

As of 2007, no antibiotics were approved for use on tilapia in the United States. However, based on reports of antibiotic resistance in bacteria recovered from tilapia, it appears antibiotics may have been misused in some countries.

To address the problem, several groups have worked in the U.S. and several developing countries to develop vaccines for *Streptococcus* and other bacterial pathogens. Vaccines greatly reduced the use of antibiotics in the salmon industry and tilapia biologists are hoping for even more success.

In addition, many farmers have learned that reducing stocking densities and/or improving water quality in production units reduce or eliminate losses from bacterial infections. Reducing stress and improving the fish environment frequently reduce the disease issue.

Carbon monoxide

Carbon monoxide has been used by some processors in various countries to maintain the appearance of fresh tilapia fillets, usually just before they are frozen. In tilapia, the gas is apparently absorbed preferentially by the myoglobin in the red-colored portion of fillets with lesser amounts in the white flesh.

Initially, processors simply laid fresh-cut fillets on trays, slid the trays into plastic bags, and then pumped gas into the bags. After several minutes, the bags were opened to remove the trays and the gas escaped. Since there were obvious worker health concerns with this process, plants switched to cabinet-style units with racks and controlled gas pumps, and more recently, units with pressurized gas.

In October 2007, a new method was observed in China in which live fish delivered to processing plants are placed in sealed tanks filled with fresh water into which carbon monoxide is pumped. The carbon monoxide the fish absorb across their gills is distributed throughout their bodies, which serves to infuse the carbon monoxide into the fillets and anesthetize the fish in one step. A variation is to deliver the carbon monoxide during transport to the processing plant.

Carbon monoxide treatment of seafood products is not allowed in many countries. In the United States and products bound for U.S. markets, there is legal ambiguity regarding the use of the gas and associated labeling requirements. A preliminary decision in 1999 recognized the use of carbon monoxide as “generally regarded as safe” (GRAS), but required labeling to denote treatment. However, critics have contended the treatment could be used to improve the appearance of inferior product or mislead consumers into consuming product that would otherwise be obviously spoiled.

Virtually all of the major processors in Latin America do not support the use of carbon monoxide and prefer that their fresh products are transported, prepared, and consumed quickly and without the use of preservatives or appearance treatments. A final decision on requirements and guidelines was pending in late 2007.

Contaminants

In the tropical countries where most tilapia are grown, several parasites with birds, fish, and/or snails as vectors are known to infect humans. Most farms attempt to exclude birds from production systems as likely predators as well as potential vectors of parasites and pathogens. Snails are likewise considered both an annoyance to equipment and potential vectors.

Predator and snail control are important in overall farm biosecurity programs. Biosecurity and wider-ranging best management practices also seek to reduce the contamination of fish by environmental pollutants. Such practices include planning for reducing pollutants that may enter farms with incoming water, air, feed, or even workers. Disinfection of nets and other equipment is an important practice.

HACCP plans help guide the operations in processing plants and back to the production of the fish. Personal hygiene is evident at most modern processing plants, which require multiple hand washings, clean uniforms, hair and face coverings, boot washes, and gloves.

Many processors now also include a chlorination or ozonated water dip for fillets before packaging. Ozonated water dips especially have been found to reduce surface bacterial counts on fillets.

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