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INSIDE –

Linking People to Research

Filter-Feeding Fish and Earthy-Musty Off-Flavor Control

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Earthy-Musty Off-Flavor

Earthy-musty off-flavor in salmon from a Scottish river was first mentioned in scientific literature in 1936. Since then, reports of similarly tainted fish and drinking water have come in from around the world.

Aquaculture-related off-flavor research conducted by Auburn University identified earthy smelling and tasting geosmin as the major off-flavor source in catfish ponds in the softer waters of eastern Alabama. High feeding rates and high water temperatures were also correlated with off-flavor there.

Mississippi State University, in conjunction with municipal drinking water researchers in California, investigated the musty smelling and tasting compound MIB (methylisoborneol)-similar structurally to geosmin, and identified *Oscillatoria chalybea* as a blue-green alga (cyanobacteria) producing it. MIB smells like camphor at higher concentrations (preliminary evidence links MIB to the pine off-flavor as well) and it is responsible for the majority of off-flavor in catfish ponds in the harder waters from west Alabama to Arkansas. Geosmin has been found to be produced by 16 species of blue-green algae and MIB by four species. In the 1992 April-June *Arkansas Aquafarming* Van der Ploeg discussed off-flavor and listed several species of *Anabaena* responsible for geosmin production in the early summer from catfish production ponds, and *Oscillatoria chalybea* which causes MIB problems in the warmer months of June to October. High production of MIB was found in healthy, actively-growing *Oscillatoria chalybea* blooms in experimental catfish production ponds in Oklahoma.

The off-flavor research at UAPB focuses on development of a colorimetric test for MIB and geosmin (with Miller of the FDA-National Center for Toxicological Research) and on off-flavor control. Results to date indicate a colorimetric test is feasible with commonly-used chemicals without a laboratory. The test will require a concentration step as MIB and geosmin are normally present at less than 100 parts per billion in off-flavor ponds. The next step would produce a color response for comparison with color strips or measurement by a Hach-style colorimeter.

Control of earthy-musty off-flavor has been elusive. Research results of chemical control (primarily copper sulphate) of algae have demonstrated no effect on off-flavor, but have indicated high risk from oxygen depletion and poor water quality. However, claims of effectiveness continue to be made. Attention has primarily focused on selective elimination of the problem species of blue-green algae. Removal of 10 percent of algae daily by flushing, mechanical filtration or filter-feeding fish has been suggested to encourage faster-growing smaller algae over the larger, slower-growing blue-greens that cause off-flavor.

Filter-Feeding Fish

Fish that are adapted to feed by straining from water microscopic plants (phytoplankton) and animals (zooplankton) and other fine organic material such as detritus are known as filter-feeders. These fishes utilize modified gill structures in "pump" feeding, which does not require swimming, or "tow net" feeding with mouth open during swimming. The intestine is normally several times the body length for increased absorption of filtered material. Zooplankton are more easily digested and consequently provide more nutrition than phytoplankton. Most filter-feeding fish feed primarily on zooplankton.

Bighead Carp

Stone reviewed current knowledge of the bighead in the April-June 1994 Arkansas Aquafarming. While the natural food of bighead is primarily zooplankton, it also consumes considerable amounts of phytoplankton. However, in preliminary tank tests conducted at UAPB, bighead had no effect on phytoplankton. In other studies phytoplankton has been shown to be poorly digested by bighead. Bighead filter feed by pumping pond water through a series of long, closely-spaced filaments (gill rakers) extending from each gill arch.

Silver Carp

Silver carp are similar to bighead in appearance, but are not as desireable for human consumption and tend to be more difficult to seine due to their jumping behavior. These carp are also pump filter-feeders, and consume smaller particles than bighead. Their filtering mechanism is a gill raker structure modified to resemble a net.

Mucous is also produced to trap, retain and swallow small particles. Although algae is consumed and digested, blue-green algae reportedly are not well digested.

A study at Auburn University found that bighead and silver carp and paddlefish reduced zooplankton numbers and increased phytoplankton relative to ponds stocked with catfish alone, but only the silver carp reduced the dominance of *Microcystis* (a common scum-forming blue-green algae) Further research on silver carp's effect on phytoplankton is needed. Hybrids may be found to combine the more docile nature and better flavor of bighead with the algae control of silver carp. A new market would be needed however for hybrids.

Gizzard and Threadfin Shad, Bigmouth Buffalo and Paddlefish

These are native U.S. filter-feeding fishes, and their common filtering mechanisms are long, closely-spaced gill rakers. Paddlefish filter by water passing through the outstretched gills during swimming. Shad and buffalo use the "pump" filtering which does not require swimming. Gizzard shad are familiar to fish farmers as trash fish in many catfish ponds. Although gizzard shad consume phytoplankton along with zooplankton and bottom sediments, digestion of algae has been shown to be selective with diatoms better digested than green or blue-green algae.

Studies at UAPB indicated no effect on water quality from the presence of gizzard shad. The smaller, more delicate threadfin shad feeds in the open water more than the gizzard shad and is killed by water temperatures below 40°F. The same limited digestion capability as in the gizzard shad may apply, but should be investigated. These shads are of limited commercial value as bait or possible forage for catfish.

Bigmouth buffalo feed near the bottom on aquatic animal life, and filter out some plant material. The limited role of phytoplankton in their diet makes their potential doubtful for algae control. Paddlefish also primarily filter zooplankton and detritus and have little effect on algae.

Tilapia

The majority of tilapia currently raised are Nile tilapia and their hybrids. A white hybrid of the Nile and blue tilapia is desired for an East Coast market. Nile and blue tilapia have similar physiology and food habits, differing slightly in color patterns and feeding structures. Their cold intolerance (death occurs at 45-50°F water temperatures) however requires overwintering.

Nile, blue, mozambique and other tilapias of the genus *Oreochromis* feed on phytoplankton as well as other plant material and organic matter including sediments and bacteria. Their filter feeding is based on mucous entanglement of algae and detritus pumped through the gills and then drawn into the esophagus by numerous tiny hooks embedded in a movable throat pad.

Tilapia have been shown to digest algae by lowering stomach pH to levels below 2 that will lyse the cells. Blue tilapia and Nile tilapia have effectively filtered larger algae (including off-flavor cyanobacteria) in laboratory tests, removing up to 100 percent in 24 hours.

Tilapia are naturally found in African lakes with dense plankton blooms of blue-green algae, which may account for their ability to efficiently filter and digest blue-green algae. In an earlier study at UAPB of blue tilapia polycultured with catfish, algal off-flavor was reduced. However, tilapia stocked in the fall into catfish ponds at the

Delta Branch Experiment Station did not reduce earthy-musty off-flavor and caused off-flavor when they were killed by low temperatures and were fed upon by the catfish.

Off-Flavor Studies at UAPB Using Filter-Feeding Fish

A review of tilapia effects on phytoplankton suggested that at stocking levels of 2000/ac and greater pond algae composition tended to be shifted away from larger species. In 1993, the initial examination was conducted of a polyculture of free-roaming fed channel catfish and unfed caged Nile tilapia. Stocking rates in six 0.1-ac ponds were 480 channel catfish and in three of the ponds an additional 200 Nile tilapia were stocked into cages. Cages eliminate reproduction (eggs will fall through the cage mesh) and feed competition and aid in harvest. Pond water was circulated daily in all ponds in the afternoon for five hours.

Averages and ranges of production results are shown in Table 1. Although catfish production was slightly reduced and feed conversion slightly worsened, these differences were not significant statistically. Tilapia grew from 23 fish/pound to 3 fish/pound. Water quality in polyculture was significantly better in TAN and unionized ammonia levels. Chlorophyll levels did not significantly differ, but variability in monoculture ponds was twice that of the polyculture ponds reflecting greater algae instability. Algae composition was altered from larger blue-greens to sheath-covered greens. At harvest approximately 20 percent of catfish had foraged on small tilapia produced by escaped cage fish.

Table 1. Production results from catfish + caged-Nile tilapia vs. catfish-only systems. Fish were grown for 84 days in three 0.1-ac ponds per system. Tilapia survivals were not determined because of reproduction from escaped fish.

System	# Stocked	Harvest Wt. (lbs.)	Survival (%)	FCR
Catfish	480	419 (341 - 454)	86 (82 - 94)	1.54 (1.41 - 1.79)
Catfish +	480	406 (397 - 414)	87 (79 - 92)	1.74 (1.68 - 1.77)
Nile tilapia	200	207 (187 - 232)	?	
	680	613 (603 - 639)		1.03 (1.07 - 1.11)

In 1994, the polyculture was repeated with larger tilapia stocked in cages to prevent escapement, with no water circulation (circulation in 1993 had depressed production) and with bighead carp stocked at 200/ac in each pond to crop zooplankton. Removal of algae by both bighead and silver carp hybrids will also be tested.

Use of a filter-feeding fish appears to offer a possible means of algae and earthy-musty off-flavor control. Which specie or species, at what stocking level, in which containment system, and with what costs and benefits remain to be determined.

Sources of Information

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Update on Drugs in Aquaculture

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As the aquaculture industry expands and becomes increasingly competitive, the use of more intensive farming techniques is inevitable. Paralleling the use of intensive farming is the increased occurrence of disease problems in aquacultured fish. This is a direct result of the higher stocking densities used in intensive farming techniques, making stress initiated disease more common while also making rapid infectious disease transmission relatively easy.

The single largest cause of economic loss in the aquaculture industry is directly attributable to disease problems of aquacultured animals, with bacterial diseases the most significant. Therefore, the need to therapeutically treat the various bacterial diseases and thus minimize the potential economic loss (i.e., animal mortality) resulting from that disease is essential to commercial aquaculture.

In contrast to beef and poultry operations, the number of approved aquaculture chemotherapeutants in the U.S. is very limited. The Food and Drug Administration (FDA) list of approved aquaculture chemotherapeutants contains only five compounds (Table 1).