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**By R. T. Lovell
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Auburn University**

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Off flavors are so prevalent in catfish that one processor last season estimated 70 percent of the fish his plant evaluated before harvest had a significant degree of off flavor. Research hasn't yet developed a guide to combat off flavors, much less determine the exact causes of off flavors. But progress is being made. Auburn University researchers know a lot more about off flavors now than they did 18 months ago, including a few tips that may help growers and processors minimize the off flavor problem. Dr. R. T. Lovell of Auburn is one researcher who has been looking into off flavors. Here's the story. —Editor.

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THE BEST THING a farmer can do when he discovers off-flavor in his fish is to replace the water in the system with fresh water. If there is no source of water except surface runoff, he may wait for rains to flush the pond. The off-flavor eventually will clear up although in many cases several months have been required. In a few instances off-flavor has essentially disappeared from catfish within two weeks with no exchange of water.

Transfer of off-flavored catfish to clean, flowing water does not show great promise for improving the flavor of the fish. Catfish which had intense earthy-musty flavor were taken from a pond at the Fisheries Research Unit at Auburn and placed in tanks through which filtered water flowed at a relatively rapid rate at a temperature of 78 to 80°F. The fish were evaluated for off-flavor at 0, 3, 5, 10 and 15 days in the flowing water. Even after 10 days, the flavor still was quite noticeable in the fish and it was not until 15 days later that the flavor was gone. The fish did not eat well in the tanks and lost a significant amount of weight.

Continued feeding in the culture system probably is a useful practice to remove off-flavor from catfish although that has not been tested under controlled conditions. If fish are not fed they may eat decomposing material from the

pond bottom and intensify off-flavor accumulation. A vigorously growing fish is in a higher metabolic state than one receiving little food which may allow for body stores to "turn over" quicker.

Destruction of algae is not recommended for clearing up off-flavor. Decomposing algae may serve as a substrate for actinomycetes growth to further augment the problem. Furthermore, decay may create a low oxygen condition.

Chemical reagents which react with the off-flavor compounds in the pond water to neutralize them possibly may be used if such a practice were found to be economical and safe.

The earthy-musty flavor, unless very mild, is difficult to mask in catfish by processing or cooking procedures. In Auburn's laboratory catfish with moderate off-flavor were soaked in 40° (brix) brine solution overnight and smoked intensively for six hours, but the

earthy-musty flavor still was perceptible to trained judges. When the off-flavor was slight, additives such as smoke, breading and seasoning were fairly effective in disguising it.

Some off flavors in commercial catfish are related to the culture environment; some perhaps are associated with supplemental feeds, and some may be the result of post-mortem bacterial or chemical changes in the fish.

Commercial catfish feeds frequently have been accused of causing off-flavor, but in most cases the real culprit was something else. Some feed ingredients, such as marine fish oil, have been found to affect fish flavor but most feed-stuffs have no deleterious effects upon catfish flavor. Bacteria-induced flavor changes can result from processed catfish being allowed to set at warm temperatures for long periods before being cooled.

Average flavor scores for off-flavored catfish held in flowing, filtered water for various lengths of time.

Score*	Holding time				
	0 days	3 days	6 days	10 days	15 days
	4.7	6.1	7.1	7.4	9.1

*10 = no off-flavor
8 = slight
6 = distinct

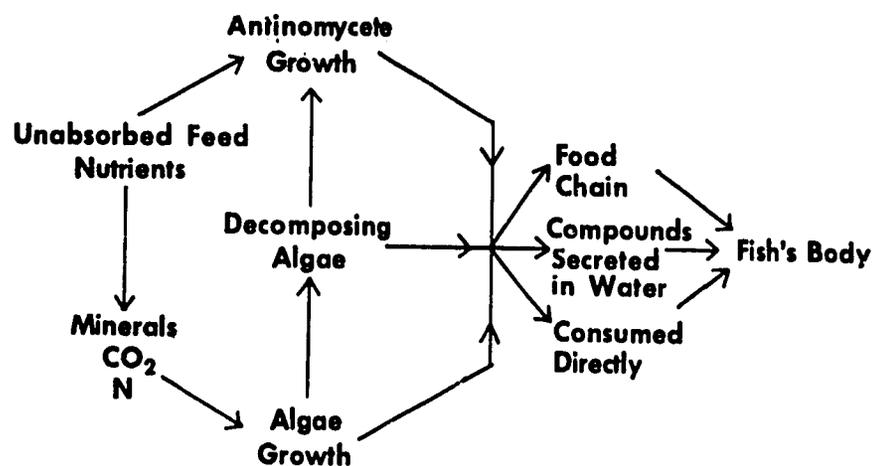
4 = intense
2 = extreme

The flavor score values in the table show that catfish with an earthy-musty flavor held in flowing, filtered water lost the off-flavor but it was a slow process.

Oxidative chemical changes in the stored processed product are considerably less in catfish flesh than in marine fish flesh. Several studies show that frozen catfish keep relatively well for 12 months or longer stored at 0° F or below. Occasionally, rancid flavor catfish are encountered which may be caused by poor storage conditions, chemical properties of the body fat, or large fish which have more dark muscle.

Off-flavors related to the culture environment are far more serious than the others because of the lack of control and understanding of sources of the off flavors and mechanisms of absorption by fish. Fish absorb a variety of compounds from their environment which can impart characteristically malodorous or unflavorful properties to the flesh. There are many reports of commercial fish from marine and fresh waters becoming unmarketable because of bad flavor attributed to a deteriorative condition of the environment. Sportsmen often report that fish taken from natural waters have objectionable flavors. Catfish, the leading freshwater food fish in the United States, are by no means immune to obtaining unpleasant odor-flavor compounds from their environment and storing them in their body.

The type of off-flavor causing most problems for the catfish industry is that produced by organisms in the culture environment. Compounds originating these organisms are absorbed by catfish and are stored in the flesh imparting an "earthy-musty" flavor. This off-flavor is highly consistent and easily distinguishable. The etiology of its origin, the mechanisms of absorption by the fish and the chemical properties of the off-flavor compounds are poorly understood, however. That makes prevention and anticipation of the onset of the off-flavor conditions extremely difficult. Moreover, satisfactory methods for removal of the flavor from affected fish and objective tests to evaluate off-flavor in fish



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ment of earthy-musty flavor in pond-cultured catfish

have not been developed.

Researchers at Auburn University have been working for the last 18 months on projects that cover the spectrum of off flavors in commercial ponds and ponds at Auburn's Fisheries Research Unit. These observations have been developed from that research:

1. Off-flavored fish were found in first-year ponds as well as in old ponds.
2. Off-flavor does not appear to be limited to specific soil types or geographic locations in the South-Central and Southeastern United States.
3. Ponds in which off-flavor was found had received large quantities of fish feed.
4. Several ponds at the Fisheries Research Unit had been intensively fed the previous year and had off-flavored fish as early as May.
5. Off-flavored fish were found in ponds at the peak of intense algae blooms a few days to several weeks following an algae die-off, and in ponds which had neither heavy algae blooms nor algae kills during the entire growing season.
6. Catfish in cages, without access to natural food from the pond, acquired off-flavors as did fish free in ponds.
7. Blue-green algae and actinomycetes, which are capable of producing earthy-musty compounds in the laboratory, were isolated from ponds having off-flavored fish.

Conclusions from our surveys are that off-flavor prevails under a variety of conditions and is difficult to predict. It is enhanced by addition of nutrients to the culture system and is characterized by conditions other than or in addition to profusely growing blue-green algae. Off-flavor compounds probably are dissolved or dispersed in the water because caged catfish were able to absorb them.

Certain species of blue-green algae appear to be one source of the earthy-musty flavor compounds. We found intense blooms of *Anabaena* species in a number of ponds at the Fisheries Research Unit in early May and fish taken from each of the ponds had a distinct earthy-musty flavor. In laboratory studies at the Taft Sanitary Engineering Center, U. S. Environmental Protection Agency, several blue-green algae synthesized an earthy-musty odorous compound which was isolated and identified as *geosmin*. That compound usually is responsible for the earthy-musty odor in natural waters.

Certain types of actinomycetes also have been found capable of producing earthy-musty compounds. Actinomycetes, which often are referred to as higher bacteria, have been named as the primary causative organisms in producing earthy-musty flavors in municipal reservoirs. There may be a symbiotic relationship between blue-green algae and actinomycetes with

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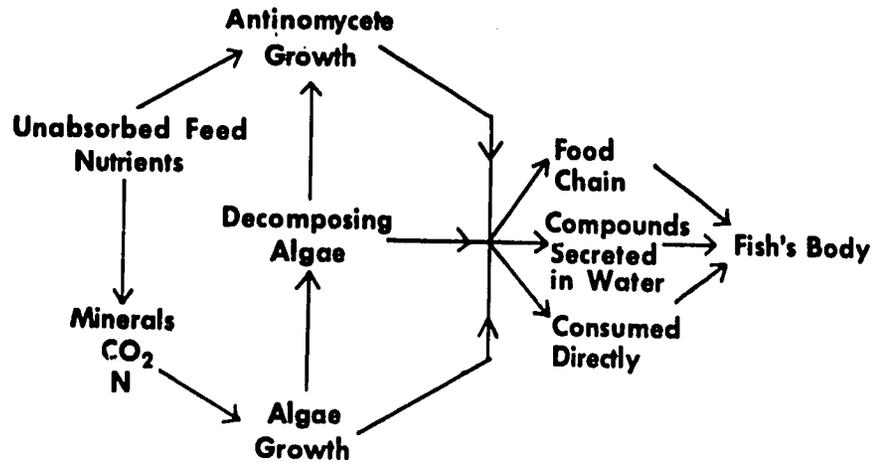
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the decaying algae serving as a food upon which the actinomycetes grow and synthesize the off-flavor compounds.

Algae may grow from inorganic nutrients in the water whereas actinomycetes need dead organic matter upon which to grow. Unconsumed fish feed may serve this purpose. Auburn researchers isolated actinomycetes from off-flavored ponds, which when grown on culture media in the laboratory, produced strong odors similar to those found in the fish.

Figure 1 illustrates suggested pathways for absorption of off-flavor by catfish. The precise origin of off-flavor compounds or their production cannot be determined at present. It is probable that more than one of the suggested pathways for off-flavor production are correct.

Prevention of off-flavor development in catfish probably is diffi-

cult in static ponds or recirculating, non-filtered raceways. On the other hand, when water in the culture system is being replaced fairly rapidly, the probability of off-flavor formation is reduced because unabsorbed nutrients are removed and dense algal growth does not develop. In ponds where unconsumed or undigested feed may accumulate, good feeding practices can be quite important. Over-feeding should be avoided. Highly digestible, nutritionally balanced feeds favor minimum nutrient waste. The use of pellets with good water stability is highly important.

The use of chemicals, such as copper sulfate, to kill algae has questionable value as a preventive measure against off-flavors. It does not remove nutrients; it only suppresses algae growth with repeated applications. Phytoplankton blooms may develop between chemical treatments and killing the algae may create an oxygen deficiency as

well as possibly contributing to off-flavor development. Removing nutrients from catfish ponds with aquatic plants such as water hyacinth has been effective in preventing algae growth at the Fisheries Research Unit. Of course, the plants must eventually be removed from the ponds. No evidence is available yet that this practice will prevent off-flavor development.

Unfortunately, there is not much to be recommended to combat off-flavor problems at present. But there is one step that growers and processors can take which will minimize the hazard of off flavors. That is to recognize that catfish are very sensitive to absorbing obnoxious flavors from the culture environment and that placing fish with an unpleasant flavor on the market will do serious and irreparable damage to the industry. These flavors can, however, be purged from the fish so that the fish can be marketed.
