

**A WHITE PAPER
ON THE STATUS AND NEEDS OF
TILAPIA AQUACULTURE
IN THE NORTH CENTRAL REGION**

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TABLE OF CONTENTS

INTRODUCTION AND JUSTIFICATION OF THE DOCUMENT	2
CURRENT STATUS OF TILAPIA AQUACULTURE	2
CRITICAL FACTORS AND RECOMMENDATIONS	4
Marketing	4
Expand Live Market	4
<i>Recommendations</i>	4
Enter Fillet Market	4
<i>Recommendation</i>	4
Identify Niche Markets	5
<i>Recommendations</i>	5
Quality Control	5
<i>Recommendations</i>	5
Promotion	5
<i>Recommendations</i>	5
Business Development/Extension	5
Business Plans and Loan Packaging	5
<i>Recommendations</i>	5
Cooperatives	6
<i>Recommendations</i>	6
Biological Technology	6
Genetic Improvement	6
<i>Recommendations</i>	6
Disease Control	6
<i>Recommendations</i>	6
Feeds and Nutrition	6
<i>Recommendations</i>	7
Reproductive Control	7
<i>Recommendations</i>	7
Recirculating Aquaculture Systems Technology	7
Cost Reduction in RASs Technology	7
<i>Recommendations</i>	7
Off-Flavor	8
<i>Recommendation</i>	8
PRIORITIZATION	8
INFORMATION CONTACTS	8
REFERENCES	9

INTRODUCTION AND JUSTIFICATION OF THE DOCUMENT

Tilapias are grown in many states in the North Central Region (NCR), and the group has been designated as high priority by the North Central Regional Aquaculture Center (NCRAC) Industry Advisory Council (IAC). Tilapias are essentially only grown in indoor water recirculating aquaculture systems (RASs) in the region. Each year, priority research areas are identified by the NCRAC IAC and presented in consultation with the Technical Committee to the NCRAC Board of Directors (Board). Concern has emanated among the various NCRAC constituencies that work plans could potentially lose focus over time and not always address the most critical factors limiting the economical and sustainable production of important species in the region. After discussions were held among members of the various committees and the Board at its February 1998 annual meeting, it was decided that a white paper should be developed on tilapias. The Board directed that the white paper not be an exhaustive literature review, but rather be a working document that clearly defines the current state of tilapia aquaculture, the critical factors limiting its economical and sustainable commercial production, and recommendations as to the research agenda that should be considered in future work plans. It is recognized that this will be a “living document” in that priorities may change based on new developments, new problems encountered, or other externalities. Industry participation and peer reviews are critical components of the process.

CURRENT STATUS OF TILAPIA AQUACULTURE

World tilapia aquaculture production doubled between 1986 and 1992, and now follows only Chinese carps and salmonids in total farm production (FAO 1994). At least 75 countries raise tilapias with the Peoples Republic of China being the largest producer (Engle 1997a). In the U.S., consumption of tilapia surpassed trout starting in 1994, and rose to nearly 100 million lb live weight equivalent (LWE) in 1997 (ATA 1998). Only salmon and channel catfish among cultured fin fishes are consumed at a higher rate in this country. Tilapias are now touted as the “new white fish” to replace the depleted ocean stocks of cod and hake (Costa-Pierce 1997). About 2 million of the 17 million lb of tilapia raised in the U.S. in 1997 were produced in the NCR (ATA 1998). Accordingly, tilapias rank as the top fish being cultured solely for food in the region.

Several species of the tilapia are raised in the United States. The most popular are Nile tilapia (*Oreochromis niloticus*), blue tilapia (*O. aureus*), Mossambique tilapia (*O. mossambicus*), and various hybrids among these and even other species (Stickney 1993). Several color strains (white, reds, pinks, “naturals”) are also cultured. Purity of species and relative species contribution among hybrids is largely unknown (Lutz 1997).

Domestic production has increased from 5 million lb in 1991 to nearly 17 million lb in 1997 (ATA 1998). The America Tilapia Association (ATA) projected production in excess of 20 million lb for 1998, but it is now believed that production will only be slightly greater than 1997 (K. Fitzsimmons, American Tilapia Association, Tucson, personal communication). Even so, tilapias are considered one of the fastest growing aquaculture groups in the United States. They are grown in nearly every state in the nation in a variety of systems (ponds, cages in ponds, indoor RASs, etc.). California was the

leading producing state in 1997 with 6.7 million lb. RASs accounted for 70% of domestic tilapia production. Virtually all tilapia produced in the NCR occurs in RASs.

Tilapias are the third largest imported aquaculture product in the U.S. being behind only shrimp and Atlantic salmon by weight (ATA 1998). Imports increased from 62 million lb LWE in 1996 to 81 million lb in 1997, a 30% increase in volume. Tilapias are imported as frozen whole (46 million lb), frozen fillets (19 million lb), and fresh fillets (16 million lb). Virtually no live tilapias are imported to be sold directly as food. Fresh and frozen fillets are mostly sold through wholesalers and distributors to retail grocers and restaurants (Engle 1997b). The frozen whole tilapia market is monopolized by Taiwan and is primarily sold to the Asian market on the West Coast. It increased 32% between 1996 and 1997. Imports of fresh and frozen imports over the same period rose 37 and 47%, respectively. Fresh fillets originate primarily from Latin America, particularly Costa Rica, Ecuador, and Jamaica. These fish are airfreighted to Miami where they are distributed to wholesalers (Engle 1997b). The jump in imported frozen fillets resulted largely from Indonesia, doubling its sales (ATA 1998). Despite the huge influx of fish via imports, only whole frozen tilapia (all imported) suffered a price decline in 1997.

Tilapia can be sold in a variety of product forms (Perkins 1994): live, fresh whole and gutted, fresh boneless fillets, skin on or skinless, frozen whole and gutted, individualized quick frozen (IQF) fillets, deep-skinned fillets, dried dressed, and smoke dressed. Value-added programs include breaded fillets, nuggets, marinated fillets, and IQF polybagged presentations (Engle 1997b). In a survey conducted by Engle (1997a), domestic tilapia producers sold to live-haulers (48%), followed by Asian wholesalers (24%; most likely in live form), restaurants and retail grocery stores (10%), and distributors and processors (5%). Thirty-five percent sold their fish on a weekly basis, 24% sold two to three times per week, and 18% sold daily. The remainder sold over two-week, monthly, or variable intervals. The primary markets for live tilapia are New York City, Toronto, Washington D.C., Los Angeles, San Francisco, and Seattle. With domestic production of tilapia expected to increase significantly over the next several years, markets within the NCR and elsewhere will need to be developed more fully. The ATA surmises that large untapped markets exist in Chicago, St. Louis, Kansas City, Atlanta, and Denver. The ATA also suggests that a large Hispanic market in the Southwest remains to be tapped. Magnuson (1991) pointed out that the Chicago/Wisconsin area consumes 159 million lb of fish and seafood annually. Between 27–39 million lb of this total consists of freshwater fish (Glecker et al. 1991).

Average prices received for domestic live tilapia on a per pound basis in 1997 ranged from \$1.25 to \$2.00 FOB farm; \$1.80 to \$2.40 wholesale; and \$2.99 to \$5.99 retail (ATA 1998). Prices for live tilapia tend to drop to \$1.25 or lower when pond producers in southern states unload their fish in late autumn before temperatures fall to lethal levels (Engle 1997b). Domestic whole fresh (on ice) prices ranged from \$1.05 to \$1.60 FOB farm, \$1.20 to \$2.00 wholesale, and \$1.99 to \$3.49 retail. Domestic fresh and frozen fillets are virtually nonexistent in the wholesale/retail market. A few farmers developed niche markets and received between \$4.00 to \$5.00 FOB farm for fillets (ATA 1998). These fish sold at retail for \$5.00 to \$8.00/lb.

Imported whole frozen tilapia on a per pound basis sold for \$0.30 to \$0.70 wholesale and between \$0.99 and \$2.99 retail (ATA 1998). Imported fresh fillets sold for \$2.50 to \$3.00 wholesale and between \$3.49 and \$4.99 retail. For imported fresh fillets, prices ranged from \$3.35 to \$3.75 wholesale and \$3.99 to \$6.99 retail.

The ATA (1998) reports that little loyalty exists among buyers of tilapia on the wholesale market. Live markets will likely be saturated in the near future if new markets are not opened. Domestic producers will require inexpensive processing to enter the fillet market to any large extent.

CRITICAL FACTORS AND RECOMMENDATIONS

To continue the impressive growth displayed in the 1990s, the U.S. tilapia industry must expand the live fish market, as well as enter the frozen and fresh fillet arena. The first issue is purely a marketing problem. Tilapia producers in the NCR are geographically positioned to capitalize on the huge market potential of the region. Marketing is needed to bring the aquaculture product and the consumer together. Ultimately, the industry must also enter the fillet market. This will require lower cost of production, improved production capability, improved quality control, and aggressive marketing. The factors most critical to the tilapia industry that need to be addressed can be categorized under: marketing, business development/extension, biological technology, and RASs technology. These four areas have not been prioritized. Recommendations under each topical heading are in priority order.

MARKETING

Expand Live Market

Live markets in the NCR need to be identified and penetrated. Chicago currently serves as the primary live market in the region. By all accounts, this market is not close to saturation, but it does take personal contacts with Asian brokers to penetrate. The ATA has identified Chicago, St. Louis, and Kansas City as potential major markets in the NCR for live tilapia. Asians and Hispanics are the primary consumer markets at this time. Other cities in the NCR may also be potential markets based on ethnicity. These markets can be identified using a combination of U.S. census data and geographic information systems as demonstrated by Kohler (1996). Once target municipalities have been identified, fish brokers, wholesalers, and distributors can be contacted using the National Fisheries Institute (NFI) "blue book," a directory of all firms involved in fish commerce in the United States. Brokers, etc. should be surveyed to determine their interests, needs, and pricing structures. This information, along with specific contacts, could then be made available to tilapia producers in the NCR.

Recommendations

- (1) Survey brokers, wholesalers, and distributors of fish for interest, needs, and pricing with respect to live tilapia.
- (2) Identify major Asian and Hispanics markets in the NCR.

Enter Fillet Market

The fillet market is not limited by consumer ethnicity. The NFI "blue book" could be used in all municipalities in the NCR to identify the best potential markets.

Recommendation

Survey brokers, wholesalers, and distributors of fish for interest, needs, and pricing with respect to tilapia fillets.

Identify Niche Markets

Marketing directly to restaurants, independent grocers, social clubs, etc., and thereby circumventing the middleman, is the most profitable channel for selling fish, at least on a small scale. Niche markets need to be developed directly by producers. A compendium of case histories where niche markets have been developed could serve as a primer for producers on niche marketing. Many producers will require training in marketing their products.

Recommendations

- (1) Develop case histories on niche marketing of tilapia.
- (2) Sponsor workshop for producers on niche marketing of tilapia.

Quality Control

Domestic supplies of tilapia need to be of the highest quality in order to have a competitive advantage to imports. The ATA is urging industry-wide purging of off-flavors and a third-party certification system to ensure an industry-wide consistent product (Engle 1997b).

Recommendations

- (1) Assist ATA in developing a third-party certification system for quality control.
- (2) Support research on off-flavor (see *RECIRCULATING AQUACULTURE SYSTEMS TECHNOLOGY* section).

Promotion

Consumers need to be educated about tilapia. Name recognition is still a problem. Engle (1997b) recommends that the tilapia industry follow the approach used by New Zealanders with orange roughy. This included detailed literature for seafood counters, demonstrations, taste tests, etc.

Recommendations

- (1) Work with ATA to develop detailed literature for seafood counters.
- (2) Promulgate recipes for tilapia dishes for display and distribution at seafood counters.
- (3) Develop a promotional video for seafood counters and other venues.

BUSINESS DEVELOPMENT/EXTENSION

Business Plans and Loan Packaging

New producers and existing producers planning to expand often need assistance in developing business plans and getting financials together to obtain loans. Norma Turoc of the Illinois Cooperative Extension Service and LaDon Swann of the Illinois/Indiana Sea Grant Program will be developing a document that describes the “thinking process” of a business plan (L. Swann, Purdue University, West Lafayette, Indiana, personal communication). This document can serve as a starting point for developing specific business plans for various producers.

Recommendations

- (1) Sponsor workshop to train aquaculture extension personnel on developing business plans and financials for tilapia producers.

- (2) Develop tilapia template for business plans and financials.

Cooperatives

The North American Fish Farmers Cooperative is the only cooperative in the NCR. Additional cooperatives need to be established in the region. These cooperatives need not be solely for tilapia. The cooperatives can serve a number of functions including: (1) purchasing feed in bulk, (2) buying supplies and equipment at discount, and (3) brokering and/or directly marketing fish to consumers.

Recommendations

- (1) Develop an extension publication on formation of cooperatives.
- (2) Sponsor workshop for producers on formation of cooperatives.

BIOLOGICAL TECHNOLOGY

Genetic Improvement

Various species, strains, and hybrids of tilapia are cultured in the NCR. It is not known which species, strain, and/or hybrid is most suited for RASs. Virtually no brood stock development of tilapia has been undertaken in the United States. Problems exist with respect to uniformity of size, fillet yields, and tolerance to RAS conditions.

Recommendations

- (1) Support species/strain/hybrid performance evaluations to determine most suitable candidates for RASs.
- (2) Support long-term brood stock development efforts to improve size uniformity, increase fillet yields, increase growth rates, and increase tolerance to RAS conditions.

Disease Control

Although tilapias are relatively resistant to diseases compared to most other cultured fin fishes, any number of pathogenic organisms still can plague them. As with all aquaculture animals, few FDA-approved therapeutants are available for tilapia. *Streptococcus* bacteria pose the most serious disease threat to the tilapia industry. Moreover, these bacteria have been known to pass from fish to humans that have handled them. New antibiotics are needed to control this disease agent. Temperature manipulation should also be evaluated as a disease control measure.

Recommendations

- (1) Support research specifically aimed at treating *Streptococcus*.
- (2) Support research aimed at registering therapeutants for tilapia.

Feeds and Nutrition

Feeds need to be formulated specifically for tilapia reared in RASs. These feeds should be formulated to reduce dissolved wastes (primarily ammonia and phosphorus) and either reduce solid wastes by being more digestible or result in solid wastes that are more amenable to mechanical removal. With feeds generally being the highest variable cost in aquaculture, there is critical need to reduce unit costs of feed and/or increase feed conversion to flesh. The NCR produces more grains

than any other region in the nation. Feeds based on regionally available ingredients need to be developed further. As fish processing plants come on-line in the region, fish offal will be available as a feed ingredient. The use of fish offal for terrestrial livestock is limited due to its nature of imparting fish odors/taste. Obviously, this is not a limitation for use in fish feeds. Diets also need to be developed that reduce fat content of fillets and improve shelf life.

Recommendations

- (1) Develop diets for tilapia reared in RASs aimed at reducing dissolved wastes and reducing and/or altering composition of solid wastes.
- (2) Develop competitive-priced diets using locally available ingredients, including fish offal.
- (3) Develop diets that reduce fat content in fillets and increase shelf life.

Reproductive Control

Male tilapias generally grow faster than females. Androgens, primarily methyltestosterone (MT), are commonly used to sex invert females to produce all-male populations. Another technique involves a combination of feminization hormones and progeny testing to produce supermales having YY chromosomes. Crossing supermales with normal XX females results in offspring that are nearly all male. Chromosome set manipulation also holds promise for controlling reproductive potential of tilapia. However, because of the small clutch size of tilapia, development of tetraploid brood stock to cross with diploids is a more practical method than directly producing triploids. Tetraploidy has been successfully achieved with tilapia (Myers 1986; Don and Avtalion 1988).

Recommendations

- (1) Evaluate non-steroidal/non-ploidy manipulation techniques for reproductive control.
- (2) Conduct pivotal research to obtain FDA approval for sex inversion using MT.
- (3) Develop efficient techniques to produce tetraploid tilapia brood stock.
- (4) Produce supermale tilapia brood stock and test progeny in performance trials

RECIRCULATING AQUACULTURE SYSTEMS TECHNOLOGY

Cost Reduction in RASs Technology

RASs are expensive to build and operate. Research is needed to reduce costs in components and in operation. RASs may only be economical when waste heat is available or when electrical costs are lower due to use of alternative energy sources such as methane found in abandoned coal-mine shafts. From an engineering standpoint, systems for removal of dissolved and solid wastes need to be improved. Oxygen consumption by fish and nitrifying bacteria is a major variable cost of a RAS. The costs of generating oxygen on-site versus purchasing bottled gas need to be compared. RAS economics could also be improved by incorporating hydroponically grown vegetables.

Recommendations

- (1) Compare costs of on-site oxygen generation versus purchasing bottled gas.
- (2) Develop improved techniques for reducing solid and dissolved wastes in RASs.
- (3) Compare mixed-sex versus all-male tilapia growth in RASs.
- (4) Identify potential sources of waste heat and/or lower cost of energy for RASs.

- (5) Examine incorporation of hydroponically grown vegetables with RASs.

Off-Flavor

Off-flavor in tilapia reared in RASs is being reported with increasing frequency. The causes, as well as means of prevention and treatment, are not well understood.

Recommendation

Determine causes of off-flavor in tilapia in RASs and develop techniques for prevention and/or treatment.

PRIORITIZATION

A number of issues concerning tilapia production in the NCR have been identified and described in the present document. Prioritizing such a list is not only difficult, but could be counter-productive. Prioritizations are largely subjective and it is unlikely that any ordering would reach consensus among tilapia producers. However, most producers would probably agree that expanding the live market beyond the few cities now being targeted is essential if tilapia producers are to survive economically. The issue of quality control, specifically that related to off-flavor problems, is another high priority area. The remaining areas of concern could just as well be listed in a random order. I have placed them in an order that I believe is reasonable based on the input I have received, but the ordering of the list is likely affected by my biases. The list should therefore only be viewed as a guide.

- (1) Expand Live Market
- (2) Quality Control
- (3) Identify Niche Markets
- (4) Cost Reduction in RASs Technology
- (5) Disease Control
- (6) Reproductive Control
- (7) Feeds and Nutrition
- (8) Genetic Improvement
- (9) Business Plans and Loan Packaging
- (10) Enter Fillet Market
- (11) Cooperatives
- (12) Promotion

INFORMATION CONTACTS

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