TILAPIA PRODUCT QUALITY AND NEW PRODUCT FORMS FOR INTERNATIONAL MARKETS

KEVIN FITZSIMMONS

University of Arizona ,Tucson, Arizona, USA
KevFitz@ag.arizona.edu

Abstract

Egypt is the second greatest producer of tilapia products, after China. However, virtually all tilapia produced in Egypt is sold on domestic markets. Egypt, with its central location on the Mediterranean and extensive trade with the European Union and the States of the Arabian Peninsula, should be a major exporter of tilapia goods as well. The current constraints to tilapia exports are: 1) Production of tilapia in sub-optimal water conditions, 2) Lack of Best Management Practices (BMP's) for production conditions, 3) Lack of sufficient Hazard Analysis at Critical Control Points (HACCP) and International Standards Organization (ISO) approved processing plants, 4) Lack of value added capabilities (freezing, breading, packaging, etc.), 5) Lack of by-product industries. These constraints should be addressed through a mix of government and private actions. Development of demonstration projects with integrated aquaculture-agriculture documenting the significant benefits of using water for aquaculture before field crop irrigation is proposed. Training in use of international standards and examples of BMP's, Good Aquaculture Practices, and Quality Assurance programs are discussed. The rapid implementation of HACCP, Codex Alimentarius, ISO, and other international certification programs are proposed. Descriptions of the current state of the art of producing, harvesting, processing, and packaging are provided, along with plans of how best to introduce these technologies. Finally, several by-product industries including tilapia skin leather, pharmaceutical uses of fish collagens, decorative use of tilapia scales, and production of bio-fuels are described.

INTRODUCTION

On a global basis, tilapia have become the second most commonly consumed farmed fish after the carps. Environmental concerns over pollution from cages and use of fish meal has slowed the growth of the salmonid industry while tilapia has continued to grow and surpass salmonid production on the basis of biomass produced, while still lagging in farm-gate value. (FAO 2006). The relative environmental friendliness of tilapia production, along with diversified production strategies and strong domestic markets in producing countries as well as growing international trade will continue to drive tilapia production and demand globally.

Tilapia consumption in the US and EU continued its steady increase through 2007. In the US, currently the largest international tilapia market for international trade, per capita consumption of tilapia grew to 518g (1.14 pounds). Tilapia solidified its place

as the fifth most popular seafood in the US, pulling further ahead of the catfishes. The huge demand for frozen fillets and frozen value added products drove much of that increase. Frozen fillets accounted for 100,636 metric tons of consumption, whole frozen fish were 51,637 mt, fresh fillets, 26,176 mt, and whole live tilapia accounted for 9,000 mt of consumption. These imports and domestic consumption added to 184,755 mt. (407 million lbs). From a production viewpoint this represents 441,074 metric tons (972 million pounds) of live weight fish.

The number and variety of value-added forms (breaded, seasoned, stuffed, etc.) have vastly increased since 2005. These processed tilapia products offer many advantages to the producer country. Additional profits are earned in country, labor is hired locally, additional ingredients can come from local markets, by-products can be sold, and the final product can be shipped more efficiently with a high price per kg. This has contributed to the increase in average price for tilapia products in international trade. Of course the obvious increases in input prices, especially feed, fuel, and transport also contribute.

Another important global trend has been the continued spread of tilapia products into the food service and restaurant sectors. Tilapia are now served in virtually all multi-national casual dining chains along with cruise ships, most dedicated seafood restaurants and increasingly at schools and hospitals. European consumers especially are now beginning to consume significant quantities and demand all across Europe is rapidly increasing. In July 2008, the EU and Egypt signed an accord liberalizing trade in seafood products. This provides a special opportunity to export tilapia products.

Egypt has been the second largest producer of tilapia in the world for many years and is the source of many of the most important strains and species used in commercial aquaculture around the world. The Nile Tilapia, *Oreochromis niloticus,* accounts for about 80% global production and several Egyptian strains have been used in the most sophisticated breeding programs.

An important factor in the increase in tilapia consumption is related to the overall increase in international trade and support groups like the World Trade Organization (WTO). The WTO was established in order to have institution governing trade relations among its members. The WTO is the successor organization to the General Agreement on Tariffs and Trade. A central role of the WTO is to help set production and product standards. An International Food Standard can be defined as any standard, guideline, or recommendation adopted by the Codex Alimentarius Commission (Codex) regarding food safety or developed under the auspices of the World Organization for Animal Health (OIE, formerly known as the Office International des Epizooties) regarding animal health and zoonoses. The OIE was established in

Paris, France, in 1924 by 28 countries and now has 172 member nations. Each country has a delegate who, in most cases, is the chief veterinary officer of that country. The WTO recognizes the OIE as the international forum for setting animal health standards (including aquatic animals), reporting global animal disease events, and presenting guidelines and recommendations on sanitary measures relating to animal health.

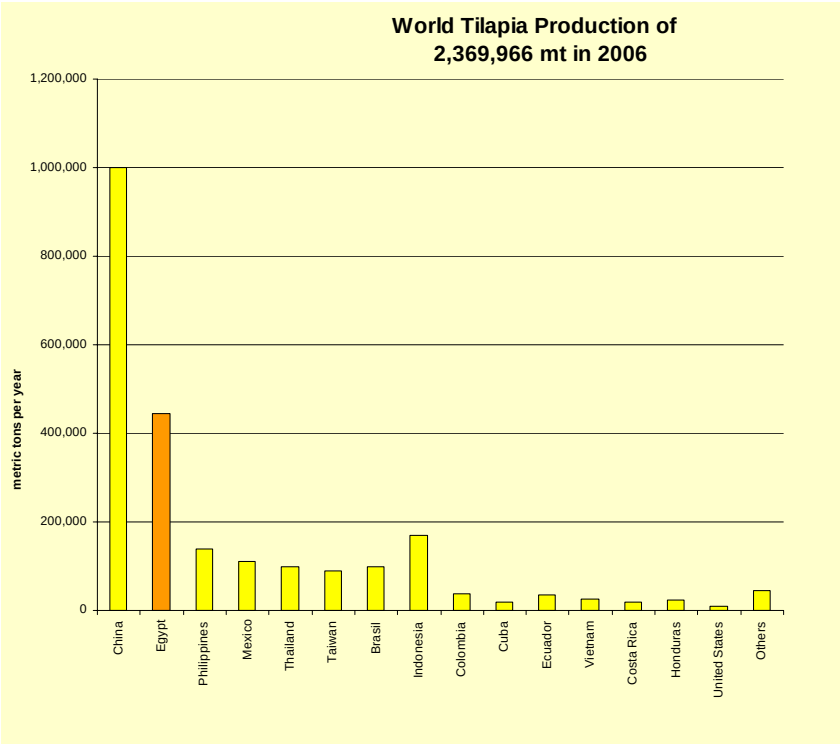

Figure 1. Global tilapia production in 2006.

Virtually all consumers are increasingly concerned about food safety and the impacts of food production on the environment. They have also learned that their purchases, when taken in total, can make a huge impact. Even the perception that they will vote with their pocketbooks is enough to induce retailers and wholesalers to pressure their suppliers to react. With the rapid increase in information transfer and ubiquity of digital cameras, images of perceived environmental mismanagement, animal cruelty, or food contamination are just as important as the facts. The tilapia industry in Egypt, if it wants to be a player in international trade, will need to address these issues and put forth an image of environmental awareness following the highest international standards of food safety and animal welfare.

METHODOLOGIES

Production – Aquaculture in Egypt has long been constrained with the stricture against first use of water for aquaculture before irrigation. While the irrigation and hydraulic engineers have their practical reasons for not wanting interference from fish farmers in their irrigation projects, there is a vast body of scientific literature that justifies the rearing of fish or shrimp in water before it is used to irrigate plants (Frei and Becker 2005; Fernando and Halwart 2004; McIntosh and Fitzsimmons 2003: Brummett 1999). The effluents containing nitrogen, phosphorus and organic matter are proven to be excellent fertilizers for plants. The slow release of nutrients from organic wastes and algae are superior to inorganic fertilizers, which are often misapplied and contribute to groundwater pollution or runoff affecting surface waters. In the US, the Environmental Protection Agency considers land application of aquaculture effluents to be a Best Management Practice (BMP). Many of the NGO aquaculture certification programs also consider integrated farming to be the preferred method of disposal of aquaculture effluents.

Production of fish in irrigation return waters is certainly an effective use of this resource (Meinzen-Dick 1997). These waters are in fact often of high quality and a vital source of farmed fish. However, there are also cases where the irrigation return waters are polluted with pesticides, fertilizer runoff, and other pollutants. Products bound for international trade are subject to strict water quality standards during rearing. In addition, the guidance practices of most of the NGO's will question the quality of fish reared in these systems, if water quality tests are not frequently collected to verify water quality.

Due to the concerns of consumers regarding the environmental impacts of aquaculture and food safety issues, several NGO's have begun to develop guidelines and standards for aquaculture production techniques and practices. Some of these have been developed in cooperation with industry and some have been developed with little or no industry input. Currently, the Aquaculture Certification Council has a draft certification plan with Best Aquaculture Practices for tilapia in the final stages of development. The World Wildlife Fund has been developing a similar set of guidelines through their Tilapia Dialogues. http://www.worldwildlife.org/what/globalmarkets/aquaculture/item5223.html These guidelines are also nearing completion. In July 2008, Whole Foods in the United States implemented their own Seafood Quality Standards: Farm Standards for Finfish and Shrimp available at http://www.wholefoodsmarket.com/products/seafood/StdsFinfishShrimp.pdf.

In Europe, the Marine Stewardship Council has decided to delay development of aquaculture standards until a future date. NaturLand in Germany has a defined plan

for organic aquaculture http://www.naturland.de/certification_aquaculture.html. These certification groups are playing an important role defining the highest standards for the most discerning customers. The important point to note is that other wholesalers will request similar standards for most growers over time.

Harvest and live transport to processor – The factors which determine the quality of farmed seafood begin on the farm and continue through harvest, transport to the processor, during processing, and then through transportation and storage until the product reach the consumer. One of the most critical of these has to do with the metabolic compounds that spread through a fish that is stressed or injured. Care should be taken to maintain good dissolved oxygen levels in water when fish are crowded for harvest and to reduce the amount of mud and debris entrained with the fish. As fish are transported to the processing plant, cooler water temperature, aeration and reduced light levels are all factors used to reduce stress levels (Fitzsimmons 2006).

Depuration systems – Many processors now prefer to utilize a depuration stage on farm or at the processing plant. The depuration facility is normally designed with clean water flowing through in order to remove any off-flavor, allow the digestive tract to empty, and to improve overall fish health and food safety. Depuration will normally last one to three days.

Fish welfare – It is common knowledge that tilapia are very hardy fish and can survive environmental and handling stresses that would certainly kill most other fish. However, reducing stress and pain for fish during production and processing has become an important topic for consumers and the research community (Ashley 2007; Volpato *et al.* 2007; Huntington *et al.* 2006; Conte 2004). The proponents of fish welfare are not making a case that fish have rights, but that reducing stress and pain is better for the fish, for the eventual quality of the fillet, and for the consumer. The science supports the argument that less stress will improve product quality. So farmers, transporters, and processors should reduce stress on their fish for both quality and consumer perceptions reasons.

Processing – There is considerable debate regarding the best manner to deliver fish to the processing plant. In China, some fish haulers inject carbon monoxide to anesthetize the fish and maintain a white appearance to the fillet. Others prefer to add ice and begin a chilling process. Hazard Analysis at Critical Control Points (HACCP) does not require any particular procedure regarding fish transport. Instead, as in other aspects, a HACCP plan must be developed for each processing plant. The plan must include descriptions of how the plant will monitor and certify that critical steps are followed in a manner to insure food safety.

There is no standard method for killing the tilapia when they arrive at a processing plant. Some plants kill with an electrical shock. Some plants use ice slurry to quickly lower the body temperature to a lethal level. Others feel it is important to bleed the fish and will cut the gills in order to quickly Others feel it is important to bleed the fish and will cut the gills in order to quickly get most of the blood from the fish. Most plants remove the head and viscera as soon as possible.

Several automated processing machines have been developed to head, gut, skin, and fillet tilapia. So far none of these machines have received much acceptance in the processing industry. Drum style scale removal, with hand filleting, followed by automatic skinning is the industry norm. This has proven to be more cost effective and provides a better yield than any of the machines in the low labor cost environment where most production and processing occur. The ISO and HACCP approvals include a strong focus on worker hygiene and processors provide frequent hand washes, foot baths, forced air currents, daily cleaning of uniforms, hair nets, gloves, and a variety of additional hygienic measures.

The most important factor is to develop the HACCP plan and have it approved and gain ISO certification after an inspection before international trade can begin in earnest. Wholesaler in Europe will demand copies of both approval documents.

Handling and processing technologies have improved markedly in recent years. Fitzsimmons (2006) provides an overview of commonly used equipment and techniques used for preparation of fresh and frozen products.

Value added products – The most common value added product is the fillet, either fresh or frozen. Even further value adding includes individually quick frozen fillets in separate packages, breaded products, seasoned fillets in sauces ready for baking or microwave, and even fillets stuffed with shrimp and lobster. The advantages of additional value-adding in the producing country are that more profit can be retained and local ingredients might be used. Also, as transportation costs increase, the higher value and lower weight of the product (compared to whole fish) decrease the percentage of transportation as an input to the final cost of the good.

Packaging – The sophistication and variety seen in packaging of tilapia products has increased rapidly. Two fillet packages for a single meal are common. These are most frequently presented in a shrink wrapped Styrofoam tray. However, we are also seeing boxed preparations with fully printed graphics. Another popular package is the one kilo re-sealable packages containing 20 or more individually wrapped fillets. These are commonly sold in the club stores and hypermarkets in the US and Europe. Twenty kilo boxes of fresh whole tilapia on ice or gel packs are used in wholesale and restaurant sales.

Figure 2. Packages for various tilapia value added products.

By-products – The variety of products recovered from processing obviously depends on the form of tilapia goods prepared for sale. Whole frozen or fresh on ice fish will have little to offer. However, fillet products generate considerable waste which can be turned into valuable products. Tilapia leather goods have become a side industry in Brazil producing wallets, belts, purses, briefcases, vests and other articles of clothing. Skins are trimmed to common size and shape, tanned in typical leather making techniques, dyed a variety of colors, sewn together, and assembled into a number of goods.

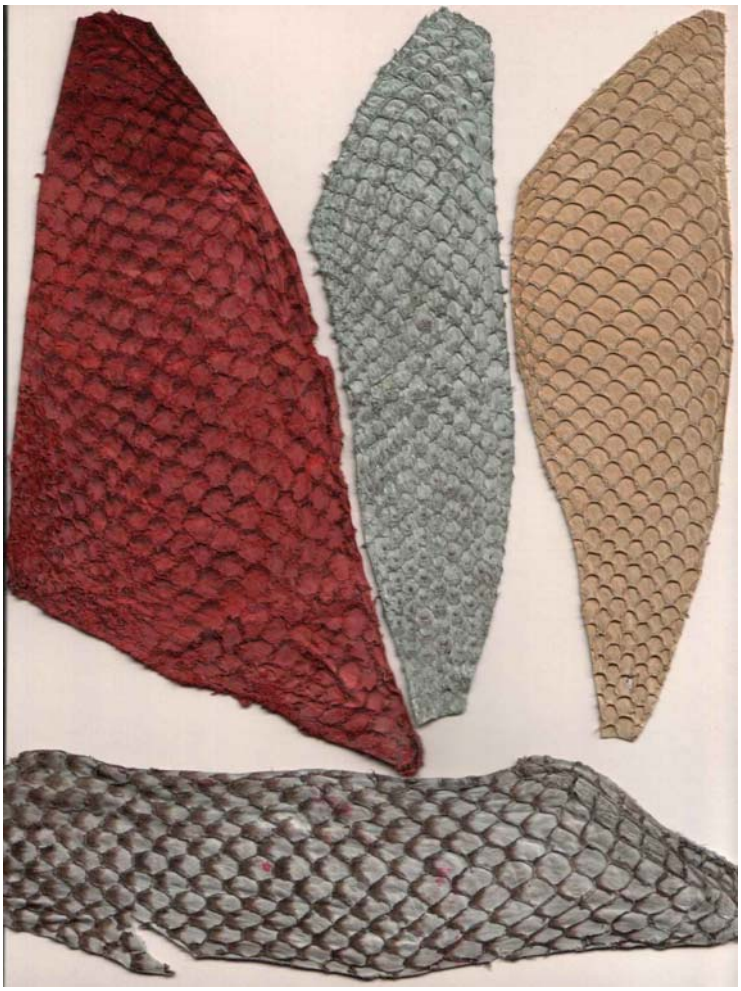

Figure 3. Tilapia skins tanned and dyed various colors.

Another important by-product is collagen collected from the inside of skins. Several countries in Europe have turned to tilapia and other fish skins to replace mammalian collagen sources due to concerns over Bovine Spongiform Encephalopathy (BSE) or Mad Cow disease. Apparently, the fish collagen can be used for preparation of time release capsules for various medicines. Skins are collected and stored in frozen blocks or salted and stored. This may a difficult market for new entry as several farms in Central America have long supplied pharmaceutical firms in the EU with product.

In several countries of Latin America, fish head soup is a popular dish and some plants will sell fish heads as a by-product, or provide them free of charge to their employees. Fish meal and fish oil derived from processed tilapia are additional products available after processing. As concerns have risen regarding the sustainability of wild fish meal and fish oil fisheries, the market value of aquaculture by-product fish meal and fish oils have garnered high prices to the processing plant. An additional product developed by a farm and processing plant in Honduras is bio-diesel from the fish oil. Finally, one of the most novel by-products is the use of Omega-3 fish oils from tilapia to fortify orange juice.

Figure 4. Orange juice fortified with omega 3 tilapia fish oil.

RECOMMENDATIONS

Production – An integrated farming operation should be designed and operated as a demonstration site using well water or direct river water. The intent would be to collect the data and demonstrate the immense benefits that accrue to both the fish farmer, using high quality water and the field crop farmer, gaining the fertilizer in the effluent and having another entity share the cost of delivering water.

Depuration – A demonstration of a fully functional tank or raceway based depuration system should be operated on a commercial basis.

Best practices – Several similar sets of best aquaculture practices have been developed by NGO's and foreign governments. Industry, government officials, and major exporters should meet to determine which sets of guidelines should be followed.

Processing plants – The Egyptian food inspection authority should cooperate with fish processing plants who wish to develop HACCP plans and obtain ISO certification. Visitation to approved tilapia processing plants in China, Thailand, or Zimbabwe should be arranged.

Value-adding and packaging – The government has a primary role of ensuring food safety and truth in packaging/labeling. It is the responsibility of the private sector to develop, or purchase, recipes and preparation styles. Also, industry needs to attend trade shows and examine products from vendors to determine which would be good investments and extensions of product lines.

By-products – The private industry should send representatives to Brazil to examine the leather industry. Egypt has a well established tanning industry which could quickly adapt the techniques to local conditions.

CONCLUSIONS

Egypt has an enormous potential to further develop its tilapia industry. The multiple use of water for aquaculture and irrigated crops should be a priority as the

demands for water and fresh foods continues to increase with rising population and standards of living. Production of high quality tilapia products for international trade should also be a priority. The technical base of trained scientists and experienced fish farmers demonstrates that only minor investments by government and industry would expand the scope of tilapia farming to be a major export earner for the entire country.

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