Tilapia Value Chain Review

Theo Simos (University of Adelaide, Australia)
Farmed Tilapia (*Oreochromis niloticus*)

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Why Tilapia?

- Worldwide production from Tilapia farming in 2010 was close to 3 million tonnes with the USA the major importer of frozen fillets sourced from South America and China.

- Tilapia was introduced into the Pacific over 50 years ago as a low cost fish farming option.

- Today it is still promoted by Aid agencies & NGO’s around the world as a subsistence food source (protein) particularly in developing countries.

- Governments in both Fiji and Samoa with international assistance including ACIAR have invested in developing basic infrastructure including hatcheries, training staff, feed mills and farm support programs particularly in rural areas.

- Relatively easy to farm and grow profitably there are few, cultural, religious or economic issues limiting development.

- Low cost production USD $2-3 /kg means Tilapia can compete with wild catch fisheries as marine resources dwindle and fuel costs for fishing increase the cost of fresh fish.

- It is a high priority Aquaculture species for the region (SPC Aquaculture Action Plan, 2007)

Background

Introduced from Africa the two main introduced species in the Pacific are *Oreochromis mossambicus* and most recently *Oreochromis niloticus* (Nile Tilapia). These fish occur in natural rivers and streams on most islands such as Papua New Guinea, Solomon, Vanuatu, Fiji, Samoa and Tonga (www.spc.int). Today Nile Tilapia is considered the most important as it has superior growth and breeding characteristics and better eating quality. Tilapia is known to inhabit a diverse range of ecological and geographical habitats which is one of the reasons why they are well established in most countries. They can live almost under any conditions (temperature, water flow, salinity, dissolved oxygen, pH, turbidity) and can grow to plague proportions and dominate indigenous species. Tilapia are generally omnivorous and primarily microphagous, feeding mainly on phytoplankton, periphyton and organic materials.
The value chain evaluation of Tilapia is one of the main components of ACIAR project PARDI 2010/002 “Value-adding and supply chain development for fisheries and aquaculture products in Fiji, and Samoa”. The project team led by Professor Robin South made up of University of South Pacific (USP) researchers has, during the course of this project, undertaken considerable investigations and scoping studies. Further Dr Jimaima Lako and her team of student researchers at USP have conducted various product and consumer trials in both Samoa and Fiji developing value added products made from farmed Tilapia (see Appendix 1 and 2). This has included developing a range of smoked, surimi and pate` products.

During 2011 researchers Ms Cheree Morris and Ms Shirleen Bala from the Institute of Marine Resources (IMR) at USP and Mr Theo Simos of Adelaide University conducted a field visit of the Fisheries research station met with farmers and evaluated the sale of live Tilapia at Nausori municipal market. A rapid assessment was also conducted in Samoa with the kind assistance of Ms Malwine Lober and Ms Joyce Samuelu Ah Leong from the Ministry of Agriculture and Fisheries.

Appendix 3 in this report provides a detailed overview of the industries in Fiji & Samoa and is designed to be read with this analysis.
Process Flow & Industry Structure

Process Flow Map
The following process is generally followed in the establishment and production of farmed Tilapia;

Phase 1: Farm Establishment.

1. Prospective Farmer submits an application for farm site survey to Fisheries Officials (soil testing, water source etc).
2. Fisheries officers visit site for assessment and approval of request.
3. Advice given to farmer on site survey by Fisheries officer to complete approval process.
4. Preparation of feasibility study for the approved farm site is undertaken.
5. Capital for funding the infrastructure will need to be secured by the farmer.
6. Construction of pond and other services is then undertaken with supervision by Fisheries officer.
7. Preparation of pond (piping, liming, manuring, filling in with water etc) is undertaken to prepare the site for production.

During Phase 1 and Phase 2, the farmer undergoes some basic instruction and training onsite.

Phase 2: Farming Tilapia

1. Supply of fingerlings (2-3 grams in size are purchased or supplied free to farms from the government run hatcheries.
2. Fingerlings are transferred to earthen or cemented fresh water ponds ranging from 5 - 90 m²
3. Fingerlings feed on algae and supplemental feeding by farmer including a range of products such as cooked cassava/ cassava peels, bele leaves, grated coconut, toasted bread crumbed, cooked breadfruit, kitchen scraps & power mesh feed by commercial feed suppliers
4. Initial feeding for Fingerlings is carried out 4 to 6 times a day depending on average body weight gain.(overfeeding can have a deleterious effect on water quality)
5. Sampling is carried out monthly during the grow-out phase to check fish growth rate and to adjust feed regimes
6. As fish develops in size feeding (generally from the 3rd month) frequency is reduced to twice daily until harvest (feed proportion 30% mornings & 70% afternoons).
7. In some cases feed regimes can be supplemented by commercial feed pellets available from feed companies.
8. Grow out to 200-250 grams per fish can vary from 4-6 months depending on operating and environmental variables.
9. Fish may be harvested progressively to be consumed by family and friends or in some cases the pond may be drained and the entire stock collected and sold fresh or live. Fish may be kept overnight in fresh water for conditioning/purging before being sold live to consumers.
10. It is estimated that from 2000 fingerlings (60-80% survival rate will yield approximately 180 kilograms of fish)
11. The number of fish per kilogram varies from 4 to 5.
12. The market value for both countries varies from FJ$6 per kg in Fiji to $7 SAT in Samoa.

Note in Fiji the major Tilapia (fingerling) supplier to farmers is the Fiji Fisheries Department, which supplies Tilapia fingerlings from the Naduruloulou Research Station. Whilst in Samoa fingerlings are supplied by the Fisheries Department hatchery in Apia.

Fish feed is also being produced and is available to farmers but is rarely used. There are two feed companies (Crest Fiji Ltd and Pacific Feeds) involved in manufacturing aquaculture feeds in Fiji whilst Samoa is serviced by a small company, Farmtech based in Apia. These companies use both local and imported ingredients. As cost of feed is a return on investment issue for many farmers who mix their own feed, as per formulations provided by both Fisheries departments.

**Consumer Markets**

Current consumption of Tilapia in both Fiji and Samoa is limited as most farms do not have sufficient pond capacity and stock to regularly meet market demands. Eating quality is considered acceptable and the price of Tilapia presents excellent value comparatively to marine fish when sold fresh or live. For example a buyer can purchase 1 kilogram (4-5 fish) for $6 in Fiji or $7 (SAT) in Samoa and this can provide sufficient serves for a family meal. Most consumption of harvested fish is by farmers, their extended families, church and community groups and some is traded or sold from the farm or roadside stalls. In Samoa there are no commercial sales and in Fiji are limited to regular sales at one municipal market located at Nausori. Intervention by the Department of Fisheries is essential to promote farm sales and improve the economic prospects of farmers. To access the farmers market in Nausori, farmers are rostered on a weekly basis and assisted by fisheries officers to harvest and transport live fish in tanks to the market. A sales program is scheduled each Saturday morning, the main market day
for seafood purchasing. Live tank facilities are used by the farmer to sell fish direct to consumers (see Fig. 1.). The nearby municipal market in Suva is not used to sell Tilapia and this limits the market development potential that can be created by exposing the product and farmers to a large urban population.

Value adding is not widely practised however whole smoked Tilapia is sold occasionally and a small company in Suva smokes small quantities regularly. It is anticipated that demand for Tilapia consumption can grow as the supply of traditional marine seafood sources reduces and the cost of fish, poultry and pork increase over time. This will depend on willingness of farmers to invest in expanding farm size, fresh fish output and improving productivity. The investment particularly in Tilapia by ACIAR, SPC and local Fisheries and Aquaculture agencies over many years has helped develop a good base for subsistence development in both countries. This foresight can now be used as the springboard for a much concerted effort to promote commercial farming and improve the availability of an alternative protein source for consumers.

Preliminary Value Chain Research

A rapid chain analysis was conducted in 2011. The approach was to conduct informal interviews and observations by ‘walking the chain’ to collect information on the industry. It included visiting farms meeting with fisheries staff, researchers and hatcheries where Tilapia fingerlings are grown and supplied to farmers.

Industry wide value chain maps for Tilapia in Fiji and Samoa are shown in Fig. 1 and Fig. 2, respectively.
Fig. 1. Industry wide value chain maps for Tilapia in Fiji

![Industry Chain Map for Tilapia in Fiji 2011](image)

- **Commercial Farms**
  - 45 farms
  - 130 Farms
  - Non-active: 125

- **Subsistence**
  - 130 Farms

- **Inputs**
  - Commercial Feed supply
  - GFW-Crest Pacific feeds
  - Naduruloulo Research Station
    - Genetics
    - Fingerling supply
    - Farm Extension
    - 220k Budget
    - 0.475 Million 2 gram Finclones

Harvest output: 95.5 tonnes
No of Farmers: 175 active
Pond capacity: 199,303 m²
No of ponds: 765
Average Pond size: 45x20m

- **Wholesaling**
  - Capacity 300 farms
  - Some carp/freshwater prawn
  - No middleman

- **Retail Trading**
  - 10 tonnes directly to market

- **Consumers**
  - Municipal market
    - Shoppers
    - Fijian Chinese Indo Chinese Nausori
    - Saturdays only
  - No organised retail
  - No restaurant consumption
  - No value adding

- **Local sales & consumption**

Farm gate value = FJS425,000

FJS 485,000 annum

Value/kg = FJ $6.00

$150/week

FJS 485,000 annum

Value/kg = FJ $6.00
Opportunities in Research for Development

As a result of the initial value chain study and industry workshop the key researchable issues to facilitate the development of the Tilapia industry were identified as:

1. Understanding the markets and potential Tilapia products through consumer and customer research;
2. In summary there seems little value in pursuing additional investment from the PARDI PRA in Samoa preferring that remaining funding is directed on the market that has the highest chance of success;
3. That further work for surimi and fish dips is set aside in favour of progressing towards a feasibility analysis of the commercial potential of the smoked variations;

4. The economics and practically of growing fish over 600 -700 g has not been done and it is recommended that a trial batch of fish is contracted & grown (using commercial feed) at a suitable location and then used for product development research purposes;

5. That a plan is developed (FFD/IMR/SPC) to be used to justify the progressive development of permanent sales outlets in Suva and Nadi municipal markets to operate on Saturday market days while continuing to maintaining the Nausori outlet;

6. This plan would also lead to the expansion of distribution to second tier markets such Sigatoka Lautoka in the west and in Lambasa to support farmers in Vanua Levu in the north;

7. That the concept is “workshopped” with prospective farmers and (FFD/IMR/SPC) and a funding proposal led by the key stakeholders be developed. This proposal would require farmer contribution as well as provide resources for the development of the commercial cluster over a 4 year period;

8. A further recommendation is that lead demonstration farm (s) be developed under the cluster development strategy and these are used to proof farming techniques, education and promotion of the category to the wider community including other PIC;

9. That a rapid chain analysis of the fresh water prawn farms is conducted with a view to determine the issues constraining development, testing market acceptance with a view to integrate development issues with Tilapia farming;

10. That a review of the role of NRS is undertaken with a view to invigorating its national and regional role and ensuring management and operational outputs are lined up with the prawn and Tilapia fresh water strategies; and

11. That future funding proposal includes establishing an industry development team (from stakeholder group) including a fulltime program development officer appointed to lead and drive the development of this industry.

References

Appendix

1/ Tilapia taste test - Samoa 2011

On July 21st 2011 a public taste evaluation for Tilapia was conducted at the Apia fish market. The purpose of the exercise was to test consumer response for Tilapia and for a select range of processed products by the public. A supply of four products including two whole smoked fish preparations was prepared under the supervision of Dr Jimaima Lako, project post-harvest specialist. The event was very successful, thanks for the careful preparation of the Fiji PARDI team in Fiji (Jimaima Lako, Cherie Morris, Shirleen Bala, Janice Natasha and Jope Lesavua) and the team in Samoa who organised and conducted the event (Robin South, Malwine Lober and Joyce Samuelu with her aquaculture staff from Samoa Fisheries).

A total of 71 questionnaires were completed, and the results are currently being analysed by Janice Natasha, ACIAR Master’s student. From preliminary results it emerged that the Tilapia Surimi and the Tilapia pate (dip) were the most preferred. There was a lot of local publicity with interviews on the local TV and Radio, and articles in the newspapers. Wider publicity was achieved when samples were also tasted by the region’s ministers of Fisheries and Finance, who were meeting in Apia the same week. Live Tilapia was also made available for sale during the tasting event, supplied by local growers, and much interest and insights on demand was generated with a number of resorts and restaurants. The next phase of the work will be to test product development of Tilapia value added items in Fiji and to follow research leads from market chain analyses.

The Tilapia consumer evaluation team, Apia Fish Market, July 21st, 2011.
Tilapia public taste evaluation, banner displayed at Apia Fish Market, Samoa
2/ Tilapia taste test - Fiji 2012

A public consumer preference test for value-added products from Tilapia was held on Saturday, 28th April, 2012 at the PSC Referral Centre in Suva City. The event was jointly organized by the Institute of Marine Resources (IMR) and Ministry of Fisheries and Forestry (MFF). The development of products and tests was co-ordinated by ACIAR sponsored student Janice Natasha who is currently completing her MSc thesis under the supervision of Dr. Jimaima Lako. A total of 155 people participated in the taste tests and some 211 questionnaires (including 56 testing extended life of Caulerpa) were completed, with results are currently being analysed. The purpose of the taste evaluation exercise was to assess the response from the general public on the acceptance, preference and willingness-to-pay of diversified value-added products from Tilapia. The products tested were: Brined and Cold-smoked Tilapia, Surimi, Pâté and Tilapia Fish-Fingers.
Tilapia public taste evaluation, in Suva Fiji
INTRODUCTION

Tilapia, named the ‘food fish of the 21st century’, is one of the most cultured freshwater fish in the world, farmed in more than 100 countries (Norman-Lopez & Bjorndal, 2009). A hardy and prolific, fast-growing tropical fish, it requires low input during grow-out periods and can be farmed successfully on any level, from extensive to intensive culture in ponds, tanks or raceways (Fitzsimmons, 2006). It is disease resistant, tolerant of poor water quality, can eat a wide range of food types and be cultured in fresh or brackish water. Chemicals and antibiotics are not necessary for commercial farming (Fitzsimmons, K. 2007). Integrated farming of crops (rice, poultry, sheep) with Tilapia is a common practice in most parts of the world (El-Sayed, 2006). They are also used in aquaponics (integration of hydroponics and aquaculture), a system where fish and plants are grown together in a recirculation system. The plants (Rakocy et al., 2004) directly use nutrients produced by the fish culture system.

Tilapia production continues to rise with global production figures predicted to reach 3.7 million tonnes by the end of 2011 (http://www.globefish.org). The growth in this field has doubled per decade with global tilapia landing (capture and culture) at 515,000 tons in 1984, over 1 million tons in 1995 (Fitzsimmons, 2000) doubling to over 2 million tons in 2006. Asia is the largest producer of farmed tilapia, contributing 75% of the world’s Tilapia production (SEAFISH, 2011) with China being the main supplier, production reaching 250,000 metric tons in the first ten months of 2010, 24% higher than the previous year, in spite of severe weather conditions. (http://www.globefish.org). The United States is the world’s single largest Tilapia importer, with imports totaling over 215,000 metric tons in 2010, at a value of USD$842 million (ERS, 2011).

Introduced into the Pacific Islands region in the 1950s, Tilapia became a commodity for culture due to its low-cost and success in other regions. For Fiji and Samoa, Tilapia was as potential pig feed and for human consumption (Costa-Pierce, 1998), although in Tonga it became an unsuccessful attempt to control mosquitoes. Fiji and Papua New Guinea both have policies of government support for Tilapia farming in rural areas. Household-scale tilapia farming is common in the Pacific but medium-scale enterprises are now on the increase (Pickering, T. 2010).

Case study 1: Tilapia by-products in the global market

By-products from Tilapia are available on the global market. Tilapia skin is used for a variety of leather goods like purses, clothing and accessories (Fitzsimmons, 2006; Fitzsimmons, 2004). Several companies in Brazil use treated and dry tilapia skin to produce dresses, skirts, vests, wallets, purses and briefcases. Another possible market for tilapia skin is as a pharmaceutical product. Several European firms are purchasing frozen or salted skins which are processed for gelatin and used to make time-released medicines, substituting material from tilapia skins for mammalian products (Fitzsimmons, 2004). Another by-product is its trimmings and heads as heads are used for soups in some countries. Fillet trimmings and throat meat can be recovered and used for ceviche and other preparations using small amounts of fish. Equipment also exists to facilitate the recovery of flesh through de-boning of skeletons. The flesh recovered provides a base for fish sticks, fish sausage, fish balls, fish sauce or other highly-processed forms. Carcasses, heads, and trimmings are also used for animal feeds (Fitzsimmons, 2004). A cottage industry in Brazil is using dry and curled tilapia scales to make ornaments, such as flowers (Fitzsimmons, 2004) and a study by Dale et al., (2004) looked at the possibility of using tilapia meal as a feed ingredient for animals such as poultry. Tilapia meal has been
Pond culture is the main culture method used in the Pacific although cage culture in a lake is practised in Vanuatu. Integrated farming of Tilapia with sheep, ducks and chicken is also practiced in Fiji, whereby the animal pen is built on top of the tilapia ponds, allowing waste to drop in the water and induce growth of primary producers (algae) which in turn are eaten by the fish. In addition, a few farmers practice polyculture of tilapia with carp and/or prawns.

In Fiji, Tilapia (*Oreochromis mossambicus*) was initially kept in Nacocolevu Agriculture Station in Sigatoka (Nandlal & Foscari, 1990; www.spc.int) but was later released into the natural river systems with some earthen ponds being stocked with Tilapia. Over the years, Tilapia became quite popular amongst the inland people of Fiji (Nandlal & Foscari, 1990) and with it, the potential for aquaculture. The freshwater aquaculture station at Naduruloulou was established in 1975 and ACIAR funded research and development of tilapia during the period 1993 to 2000. Several introductions of a better performing species (*Oreochromis niloticus*) and strains were introduced and a better performing strain was obtained and helped small-scale Fijian farmers improve the productivity and profitability of tilapia farming. The Fiji Fisheries Department has assisted other Pacific Island countries develop and improve tilapia farming through the training of fisheries officers and the supply of fry. Currently Tilapia is found in most major rivers systems of Fiji as well as some outer islands. There are approximately 300 tilapia farmers around Fiji (Figure 1), out of which 50 are commercial farmers, the rest being semi-commercial (100) and subsistence (150); (Source: Presentation by Principle Aquaculture officer, Commodity Task Force meeting, 2010). Estimated annual Tilapia production recorded 284.9 tons in 2007 and 182.3 tons in 2008, valued at FJ$1.4 million and FJ$0.9 million respectively (Fisheries Annual Report, 2007: 2008). Tilapia currently sells for FJ$5-6 per kilogram.

In Samoa, Tilapia (*O. mossambicus*) was introduced in 1955 (Bell et al. 1997; www.spc.int), after its potential as a candidate for pond culture was investigated by SPC (www.spc.int). Following this, the Fisheries Division of Samoa introduced a better performing *O. niloticus* for aquaculture, under its South Pacific Aquaculture Development Project (SPADP), in 1991. Tilapia has been a subsistence fishery in a few villages, but utilized at a larger scale in Savaii (Bell et al., 1997). They have been released in main freshwater river systems in Savaii for subsistence (www.spc.int). In 1996, several demonstration ponds

Fig. 1. Map of Fiji showing the distribution of tilapia farms (red) and major markets (1-6).
were constructed under the SPADP and Fisheries Division (Nandlal, 1996). By late 2000, Samoa had 19 tilapia farms in total, 11 on Upolu and 8 on Savaii (Su’a et al., 2009).

Currently, there are approximately 27 farmers out of which 5 are semi-commercial and 22 are subsistence. Annual production from 4 semi-commercial farms located at Vailele, Falese’ela (Figure 2) and Falelauniu (on Upolu Island) is conservatively estimated at 862 kg. In addition to these farms, 3 communities harvest Tilapia from natural water bodies. These are communities of Faleapuna and Saoluafa-ta on Upolu and Satoa-lepai on Savaii Islands.

These fishermen use nets and spears for catching Tilapia, crabs and eels for the family meal. On a good fishing trip, there can be 20 tilapia caught but on average 4 - 5 tilapia were caught per week ranging from 0.8 to 2 kg in size.

Fig. 2. Map of Samoa showing the semi-commercial farm sites on Upolu
In Tonga, the aquaculture of Tilapia is nonexistent. Initially, in the 1950s tilapia (*Oreochromis mossambicus*) was introduced in an unsuccessful attempt to control mosquitoes. The culture of Tilapia, integrated with piggery was later trialed at Sopu with unsuccessful results. Tilapia is believed to have spread to neighbouring areas and also introduced to several outer islands in Tonga during this time ([www.spc.int](http://www.spc.int)) but there are no records of Tilapia fishery. The "Tonga Aquaculture Commodity Development Plan 2010-2014" has identified commodities but Tilapia is not on the priority list, being considered as having medium importance and impact.

**Case Study 2: Nadala women learn new skills in fish farming**

"Women in rural areas are known for their skills and talents in making use of natural resources to earn a living for their families. An inspiring story is unveiled in Driti Village in the Tikina of Dama where women have taken the lead role in managing six fish ponds that is a source of income and most importantly supplements the protein intake villagers desperately lack in their daily diet. Established in 2002 by the Department of Fisheries, Ministry of Women, Secretariat of the Pacific Community and University of the South Pacific Marine Studies the project was handed over to Driti women. Known as the Seatura Women’s Club Aquaculture project the two main objectives met by the initiative are: Create source of income for the women and sustain their nutrition level.

According to Seatura Women’s Club leader Narieta Leba about 40 women benefit from the project and the revenue earned is deposited into a fixed savings account while portion of the money is used to meet miscellaneous expenses. “Most of the money is kept in the bank for education purposes of the children in the village and in total from the fish project and the honey the women have managed to save a total of $26,000 in the savings account. During the harvest we are able to earn $1000 to $2000 a month,” said Leba. She said the fish was supplied to the nearby villages and Bua School at reasonable prices and there were plans to expand the market to Labasa Town.”

**Fig. 3.** Tilapia cement pond, EFKS, Samoa (Photos: Falese’ela, Lefaga)

**Fig. 4.** Earthen ponds at one of the commercial freshwater farms in Fiji (Photos: Avinash Singh)
According to the Fisheries Aquaculture Officer, there has been some interest in the subsistence production of Tilapia and farming Tilapia for pig food. Tilapia exists in estuarine waters in the lagoons and lakes in Tongatapu, Vavau, 'Eua and Ha'apai and grow to a large size (individuals are likely to be in the range of 800 g to 1 kg). On the island of 'Eua, there is no intertidal area and Tilapia is a major protein source for the residents who harvest it from the lake. However, Tilapia may be given higher priority in the future given the decline in inshore fisheries and the high cost of living (Personnel Communication, Poasi Ngaluafe, April, 2011).

VALUE-ADDING

The increasing demand for Tilapia has also seen an increased number of value added products. In the 1980s, the only Tilapia product in the international market was whole frozen fillets, but with increasing demands, exporting countries started producing and exporting in increased quantity and quality (processed). The major Tilapia producing countries produce tilapia as whole frozen, IQF fillets, fresh fillets and sashimi.

Case Study 3: MSc research on “Value-addition of Oreochromis niloticus (Tilapia)”

While a great deal is known of the socio-economic aspects of Tilapia, little has been done on product enhancement. A current MSc research at USP by Janice Natasha is looking at the value-adding of Tilapia, a fisheries commodity in Fiji. The demand is extensive but it is being sold live only in the local markets. However, most consumers do not prefer Tilapia because of its characteristic tasteless meat. This project proposes to investigate possible product enhancement methods that can be used at the community level and for potential commercialisation such as the salting of Tilapia as a pre-treatment to further product enhancement such as drying, smoking, freezing and canning.

The United States is one of the major importers in Tilapia products and the product range includes fillet of different sizes (3-5 oz, 4-6oz, 5-7oz, 6-8oz etc) and packages; with skin off or on; deep skinned; ozone-dipped; carbon monoxide treated; individually quick frozen; smoked; liquid smoked and in sashimi grade (Fitzsimmons, 2004; Lim and Webster 2006). Individually frozen whole fish can be either marketed in individual plastic bags or individual Styrofoam trays with plastic wrap for retail sales. Similar options are available for fresh or frozen fillets.

Most fillets now also go through hand trimming with the dorsal and ventral margins trimmed off leaving nicely rounded edges and a smooth appearance. Fitzsimmons (2004) noted that many processing plants ran their trimmed fillets through a water bath after trimming and whereas in the past, some plants used a mild chlorine solution to reduce bacteria and lengthen shelf life, nowadays, most plants use ozone gas, which is bubbled into the tank. Ozone treated fillets are not subject to the disinfection by-products that chlorine can form with organic molecules nor does it leave any disagreeable taste that can be discerned by some consumers. “Most plants use an on-site ozone generation system that supplies the small amounts of ozone needed to effectively disinfect fillets. Studies conducted at the University of Arizona demonstrated that bacterial counts could be lowered by several degrees of magnitude and shelf life could be extended by several days when fillets were rinsed with ozonated water compared to untreated fillets.

Tilapia skin is also sold on the international market as frozen or in salted and deep fried forms. In Thailand and the Philippines, skins are scaled, cut into thin strips and deep-fried, as appetizers served with a slice of onion and cut lime (Fitzsimmons, 2004).

Efforts in value adding of tilapia have been minimal in the Pacific (www.spc.int). Tilapia is mostly sold live or fresh in bundles but interestingly in Papua New Guinea, cooked tilapia (fried) is sold on the
roadsides (Ponia & Mobiha, 2002). The Tebara Meats (previously Dairy Farms Fiji Limited) aquaculture unit in Fiji sells it frozen. Simple village level post harvest processing, such as smoking may exist in some countries (www.spc.int) but proper documentation is absent.

In Fiji value-adding has been conducted on an experimental basis by some University of the South Pacific (USP) staff and students and a businessman does small-scale tilapia smoking but village-level smoking also exists. Terry Mandam runs a small family business and has been selling smoked fish including Tilapia since 1985. He buys live Tilapia from the Nausori market (FJD5.00 for 4 fish), smokes, vacuum packs and sells them for FJD12.00. Mr. Mandam cold smokes (30-40 °C) Tilapia on order or for research purposes. The smoker used is homemade (made using a 44 gallon drum) and the design can be adopted by farmers at minimal cost. Fish are gilled, gutted, scaled and brined; followed by a quick freshwater dip and fan drying (Figure 4). Prior to fan drying, a small stick is used to open the stomach of each fish. Once dried, the fish are hung on metal rods and placed vertically in the smoker. The whole process from brining to the smoked product takes approximately 8 hours. The smoked fish are then cooled, vacuum packed and stored in a freezer until it is ready to be cooked. Mandam believes that value adding of Tilapia has great potential in Fiji and needs to be taken to a commercial level.

Fish processing and quality standards in Fiji are in place and the same protocols can be adopted for future Tilapia processing/value adding. The Fiji Fisheries Department has a Product Development and Utilization (PDU) unit, which assists fish processors (such as Fiji Fish, Golden Ocean Fish, Tosa Bussan Fiji, Solander Pacific, Tripacific Marine, Celtrock Holdings etc) achieve quality products of international standards for local and export markets. These standards include, the European Union Food Safety, United States Food and Drug Administration, and Hazard Analysis and Critical Control Points (Fisheries Annual Report 2008). Processing companies process deep sea fish such as tuna (yellowfin, bigeye and albacore), marlin, sword fish etc. Fish are exported fresh or frozen, whole gilled & gutted, headed gilled & gutted. These companies also vacuum pack fresh and/or frozen loins and steaks.

High quality chilled and processed tuna are also exported to Japan, Europe and United States. Two companies, PAFCO and Voko Industries are involved in canning (FTIB, 2009).

In a case study by Prasad (2006), fishing contributed about 2.4% to Fiji’s GDP in 2001 however, this does not provide the whole picture as fish processing and post harvest activities are considered within other sectors of Fiji’s economy. Summarized data from the Fiji Bureau of Statistics indicates that export of fishery products account for approximately 9% of the total domestic export from Fiji.

A taste study of smoked Tilapia in Samoa showed that some people (33%) preferred smoked tilapia over smoked reef fish (Bell et al., 1997), which suggests that fish smoking (tilapia and other species) is being practiced in Samoa. Generally, there is no value adding of Tilapia in Samoa.
CONSUMER INFORMATION

In Fiji, the major consumers of tilapia are the indigenous Fijians while Chinese and Indo-Fijians purchase tilapia from the municipal markets at a smaller scale. These prefer to buy live, plate size tilapia, that is, 4-6 fish per kilogram. Indigenous Fijians do not prefer larger-sized fish (2-3 per kg) as smaller fish allows each member in the family to have one whole fish per plate.

There are no hotels or restaurants that are known to purchase tilapia however, consumer/market testing can be done once value-added tilapia products are available and introduced into the local markets.
In Samoa, the major consumers of tilapia are the locals while expatriate Asians and Africans have also been reported buying tilapia from one of the farms. Chinese restaurant owners in Samoa usually bought for restaurant menus and for their own consumption. The communities of Saoluafata and Faleapuna on Upolu Island and Satoalepai in Savaii Island who are involved in the tilapia fishery consider tilapia as a staple protein source especially in the latter where tilapia strings were sold along the roadside.

**PRELIMINARY ANALYSIS OF THE SUPPLY CHAIN**

In Samoa, the Savaii and Upolu market/supply chain occurs over a 6 - 12 month cycle as follows:

1. Farm-based harvesting (partial or complete) with assistance from Fisheries Department
2. a. Product sold live (and occasionally gutted and scaled) to consumers from the farm or
   b. transported to restaurants for sale or
   c. transported to municipal markets and sold live to consumers on Saturdays?
3. Consumption by non-commercial and commercial users

In Fiji, the market/supply chain occurs over a 4 - 6 month cycle as such:

4. Farm-based harvesting (partial or complete) with assistance from Fisheries Department
5. Transport to the market live in tanks or alternately sold live to consumers from the farm
6. Sale of live fish in municipal markets on Saturdays to consumers
7. Consumption by non-commercial users

The cash flow steps for Fiji are:

1. Transportation and related costs to the market
2. Percentage loss of product due to handling (mortality)
3. Purchase price of Tilapia to farmers
4. Income to farmers

*Figure 3: Tilapia being sold live at Naucori market. Top L and R: temporary holding tanks for live sales of tilapia at Naucori market. Bottom L and R: scoring and choosing fish as per customer preference.*
Case Study 4: The cost structure of tilapia farming in Samoa based on an average pond size of 5m x 10m

Capital involves machinery to clear land if it’s new land for the pond(s). Construction of ponds and plumbing are the other two main factors which are required for tilapia farming.

1. Labour: In Samoa, the workers do not cost their labour, as tilapia farm management becomes a family activity. However when there is harvesting then the catch is distributed to neighbours and relatives depending on the catch or to other people that assisted during the farming and harvesting.

2. Operating Expenses: For subsistence farmers, the main operational cost is feed. The main use of fuel on the farm is mowing grass or cutting down nearby trees threatening pond stability and shading over the ponds and transport to buy the feed from the store.

3. Purchase of Fingerlings: The Fisheries Division (FD) of the Ministry of Agriculture of Fisheries is the main supplier of tilapia fingerlings to the local tilapia farmers. Currently the fingerlings are free of charge for initial stocking. Should the industry expand there will be a need for the FD hatchery to expand to meet the demand and set prices to sell fingerlings.

4. Feeds: The feed currently used by the FD is a combination of fish meal, coconut meal and brewery waste from Vailima Brewery Company. The pellet machine has enabled the production of pellets for feed now sold at $3 / kg. Fisheries had assisted Farmtech Company Limited in producing the same feed using the FD’s formulation. The formulation has been modified by the company replacing the brewery waste with the mashed cassava. Most of the tilapia farmers in Samoa farm for food security and are advised to utilize pele and cassava leaves that are readily available.

Tilapia production and growth rates

Statistical data on tilapia production and growth is very hard to obtain as these farmers do not consider it vital. However the Fisheries Division is training local tilapia farmers to make an effort to take simple recordings of their daily operations as the information is vital for their developments if they so wish to expand or commercialize.

A total of 8,034 tilapia fingerlings were distributed to eight new farmers (7 in Upolu and 1 in Savaii) and restocking of 18 existing farms in Upolu. Overall an average size of 9 cm fingerlings was distributed at an estimated weight of 9.5 g, presuming the estimated tilapia produced and distributed at this fiscal year (2010 – 2011) will be 886.97 kg.

Quarterly monitoring of stocked farms calculated an average growth of tilapia at 1.24cm/month or 105g/month and an annual survival rate of 85%. Thus estimation when harvested will be expected for the stocks to reach average size of 18 cm or average weight of 750 g, thus a total weight of harvested stocks with an 85 % will be 51,217.5 kg or 51 tonnes.

5. Marketing

Tilapia in Samoa is mainly consumed by the subsistence market. However past trials of sales of tilapia at the Apia Fish Market was successful at $5/kg. Future opportunities lie in the potential export of tilapia. In 2009 a tilapia farm was established at Vailele by business man, Sala Vaimili. The pond is fed with water diverted from the river adjacent to the farmer’s land. The pond size is estimated at 96 m². The pond was initially stocked with 3000 fingerlings with total weight of 39kg. After 8 months of culture, 1980 fish (600 kg) were harvested. Sala’s tilapia was distributed to his relatives and friends as it was his first harvest.

6. Risk Analysis

Using the model developed by AusAID project in 2005, we can assume that the risks (natural disasters, theft, disease, lack of fry supply) for a typical tilapia farm range between a probability of 10-40%.

Source: Fisheries Division, Ministry of Agriculture and Fisheries, Apia, Samoa, March 2011.
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http://www.globefish.org
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