# Production of tilapia for export : II. Compact, modular super-intensive production systems

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The predominant production system for production of tilapia in Colombia is the semi-intensive or extensive system, which uses large earthen ponds with limited exchange of water and no addition of aeration. It is thought that such systems are cost effective because the investment and operating cost per hectare are low and because they are thought to be less risky. However, there are many disadvantages to the extensive methods. The trend in aquaculture is toward intensification, and the same should be considered in Colombia. This is especially relevant to the production of tilapia and other fish. The aim of this article is to present the main features of the Super Intensive, Compact and Modular (SICM) production unit for tilapia, and other fish.

Although tilapia and shrimp share the aquatic environment, the SICM for tilapia is more like poultry production. Poultry represents the most successful animal husbandry system, with full control of the reproduction cycle, and super intensive production carried out in modular, compact units, which can be established anywhere. Tilapia production follows these footsteps. In Israel, and in numerous other countries, tilapia and other fish are raised commercially in SICM systems for many years. In fact, the conversion of tilapia from a low quality, small fish, with non-uniform appearance and with 'muddy' taste, into a prime standard quality product, with high demand and recognition in the developed markets was made possible by the introduction of the SICM systems, described here. The main features of these systems are:

**Product quality:** Aquaculture is in the business of producing high quality consumer food items. Fresh fish out of the production ponds, should arrive directly, or after minor processing, at the 'white table cloth' restaurants and hotels in Mexico and in the USA. As in poultry, demand is high for fresh, non frozen products. To accommodate the market demand and to secure high price the production system must ensure excellent taste, uniform and standard appearance of the product and reliable supply on a year round basis. The use of SICM provide the necessary quality assurance required for export to the developed markets: : In Japan, Israel and the USA, live tilapia directly from SICM ponds are eaten raw, as "sushi".

**Production line**: A complete and self sufficient production line can be established on site. This includes all the facilities required for holding parental lines of genetically improved tilapia strains, spawning and alevine ponds, sex-reversal ponds, nursery and grow out ponds and a fish processing plant. The production of alevines and the processing and marketing of the final product

need not be an integral component of every project. Regional commercial centers for fry production and processing can operate as separate entities. The production line can be divided between a **Central Farm**, which supplies alevines, feed, materials, and processing and marketing services, and **Associated Growers**, who specialize in the grow out phase. The similarity with the poultry industry is quite apparent. This strategy allows equitable and reasonable participation of large coprporation and small producers, cooperatives and rural enterprenuers in the establishment of tilapia industry. .

**Facilities:** The key wards are ***compact, modular, multi-purpose, production flexibilbity and quality control***. Each of the main steps mentioned above is carried out in small ponds, not larger than 500 cubic meters. Additional units can be added as required, according to market demand, availability of capital and the investment plans. Each of the pond structures can be used for a variety of functions. The 300 square meter, plastic lined ponds used for holding the brood stock, also serve for spawning and for sex reversal. The 500 cubic meter ponds used for growing the fish up to 800-900 gram, can also be used for nursery. Moreover, unlike both shrimp and poultry, the SICM system can be used equally well for other exportable species, such as *channel catfish, hybrid striped bass* and *silver perch* in fresh water, or *sea bass* and *sea bream* in saline water*, a*ll of which are possible candidates for future introduction into Mexico's developing aquaculture. This is considered a multi-purpose system.

**Quality control:** The taste of the fish is influenced by method of growing, the feed and the contact with pond bottom. "Off-flavor", or muddy flavor, is a problem not only in tilapia, but also appears in shrimp. In the SICM system, this problem does not exist due to the fast exchange of water and the nature of the pond bottom.

**Production capacity:** Tilapia has a significant advantage over shrimp and poultry, both of which require the surface area of the pond or the cage and therefore use the *two dimension* of the production facility. Fish, on the other hand, occupies the water column and uses the *three dimension* of the water volume. Therefore the production potential of fish is higher. The production efficiency is determined by the nature of the fish (its biological growth pattern and its genetic type) and by the nature of the production system (maintaining oxygen regime, water exchange rate, the accumulation and wastes and the ability to remove those wastes, water quality etc.). The most important factor to consider in aquaculture is the ***production capacity***, which takes into account the contribution of the fish, and that of the production system. It is defined as the *amount of biomass produced per area per time (kg/ha/day).* The biomass is defined by *number of fish per* $m^3$ *x the average weight* . The rate of increase of biomass is obtained by multiplying *biomass X the daily growth.* The *daily growth* is an inherent biological trait of the fish species and its genetic type. It varies as a function of the weight of the fish. Therefore, for each weight of fish, the daily growth rate is different. It is important to note that **density** (number of fish per unit area) is not a main factor characterizing the production system. This is because the density varies during the production cycle, according to the average weight of the fish. If the fish are small, than the density will be increased up to the limit, allowing maximum net daily production.

The ***production capacity*** of the SICM system is between 20-40 kg per cubic meter per year, equivalent to 200 to 400 tons per hectare per year. This is significantly higher than any shrimp system, but it is not considered highest as far as intensive fish production is concerned. Higher production capacity, around 100 kg per cubic meter per year (equivalent to 1000 ton per ha per year), are obtained in "Industrial" aquaculture units. Such systems are not recommended, not required for Mexico. The high and low in the range mentioned above (namely, 20 to 40 kg per $m^3$) is determined by any of the factors mentioned above, for example, the water flow rate, the ability to supply sufficient oxygen or remove the wastes.

**Area required:** When it comes to area, the advantages of the SICM system begin to emerge. For a production of 500 tons per year, the water area required for the grow out ponds is only 1.25 to 2.5 hectares. The total area, including the service ponds and the auxiliary systems may amount to 5-7 ha, plus any similar amount one would consider for future expansion. While the investment per hectare is significantly higher than the investment per ha of shrimp ponds, the investment per ton of product produced is lower. To this, add other operational advantages: it is easy to manage, supervise, control and protect a 5-7 ha project. With a fence you can protect against theft. In a few moments you can reach any location to solve problems, and to ensure that even the remote points in the farm receive the appropriate feeding and attention.

Since the area required for a commercial size project is relatively small, land is not a major factor and it becomes possible to construct and implement this production system in a variety of locations, according to land ownership, availability of infrastructure, marketing routes, etc. The modest requirement for land reduces the competition for land against other agricultural and animal husbandry activities and enables true diversification in the farm. Here again, emerges the similarity to the poultry industry, in which compact chicken production units are constructed everywhere, and in association with other agricultural branches. This is contrary to shrimp culture, which requires vast areas, and is restricted to remote and narrow coast land.

While land is not a major factor in determining the location of the SICM project, the one important factor is the water source.

**Water sources:** Tilapia can grow and reproduce in variety of water types. Today there are genetic strains which maintain positive economic traits (high growth rate, uniform body shape, uniform color, resistance to disease and) and are adapted to fresh, or brackish or sea water. This open the way to establish SICM's on the seacoast, near estuaries and in-land, on agricultural land. Here are some examples of possible fresh water sources: Irrigation canals, impounding reservoirs, wells, lakes, rivers. If water is available by gravitation, then costly pumping is reduced. If water from an irrigation system is used, it will be returned to irrigate crops without any significant loss. The integration of aquaculture and irrigation will be the subject of the next article.

The SICM system requires fast exchange of water in the ponds, between 100-700% per day, to ensure dilution of the soluble organic wastes, the flushing out of the solid particulate wastes, and to partially supply oxygen. Considering the small volume of the pond, the required flow is modest. For example, for

production of 200 tons of fish the volume of SICM pond area is 1 ha, or 10,000 $m^3$. An exchange of 100% day is equivalent to 416 $m^3$/hour, or about 1700 gpm. This quantity can be supplied from existing wells in agricultural areas.

The water supply and drainage systems of the SICM, and the treatment of the wastes, requires close attention to local site conditions and requires qualified engineering experience. If correctly designed, the SICM can be constructed as "environmentally friendly" production system.

In summary, after the success of shrimp culture, Colombia is ready to begin with fish aquaculture. However, reliable fish culture can not be carried out effectively in extensive system. The use of SICM's is the best option.