**60 YEARS OF TILAPIA AQUACULTURE IN NIGERIA**

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**INTRODUCTION**

Nigeria is the second largest producer of farm-raised tilapias in Africa, after Egypt (Adesulu, 1997; Fagbenro, 2002; El-Sayed, 2006; Fagbenro *et al*., 2010). The first attempt at fish farming was in 1951 at a small experimental station in Onikan and various *Tilapia* species were used. Modern pond culture started with a pilot fish farm (20 ha) in Panyam for rearing the common/mirror carp, *Cyprinus carpio*, following the disappointing results with tilapias. Although the first years of Panyam fish farm's existence were hardly satisfactory, the trials nevertheless generated sufficient interest that regional governments established more fish farms. Tilapias are widely cultivated in ponds, reservoirs and cages in Nigeria (Satia, 1990; Fagbenro et al., 2004) and are suited to low-technology farming systems because of their fast growth rate, efficient use of natural aquatic foods, propensity to consume a variety of supplementary feeds, omnivorous food habits, resistance to disease and handling, ease of reproduction in captivity, and tolerance to wide ranges of environmental conditions (Fagbenro, 1987).

Tilapia culture in Nigeria remained largely a subsistence level activity until 2000, when it began to expand rapidly following the successful commercial farming of catfishes during the last decade (Alfred and Fagbenro, 2006; Afolabi *et al*., 2007). There are over 25 species of tilapias in Nigeria, out of which about six species are used for aquaculture, namely, *Tilapia zillii, T. guineensis* (substrate spawners, macro-phytophagous (generally herbivorous)*, Sarotherodon* *galilaeus*, *S. melanotheron* (bi-parental mouth-brooders, micro-phytophagous (planktophagous), *Oreochromis niloticus* and *O. aureus* (maternal mouth-brooders, omnivorous). The natural feeding habits of cultivated tilapias in Nigeria are summarised in Table 1.

Table 1: Natural feeding ecology of tilapias used in fish culture in Nigeria.

|  |  |
| --- | --- |
| Species  | Food habits |
| *O. aureus* | Adults omnivorous. Fry feed initially on zooplankton. Exclusively phytoplanktivorous. |
| *O. niloticus* | Omnivorous grazer. Feeds on algae but not higher plants. |
| *S. galilaeus* *S. melanotheron* | Adults feed almost exclusively on phytoplankton. Juveniles feed on plankton. |
| *T. guineensis, T. Zillii* | Adults feed exclusively on higher plants. Juveniles consume plankton. |

Sources: Idodo-Umeh (2003), Adesulu and Sydenham (2007)

**TILAPIA FARMING/PRODUCTION SYSTEMS**

Tilapia is cultivated in a tremendous diversity of production systems, in ponds, cages, *hapas*, raceways, concrete tanks, from extensive to super-intensive practices at small-scale and large-scale level, for self-consumption or marketing and even processing purposes. The technology for tilapia farming is well established and tested, ranging in production from 200 kg.ha-1.yr-1 in stocked rice paddies to over 2000 mt.ha.yr-1 in the more intensive tank culture system. Tilapia aquaculture industry produced 14,388 tonnes in 2000 and increased to 19,546 tonnes in 2005; and was based mainly on *O. niloticus* (Fagbenro and Adebayo, 2005; Ayinla, 2007), cultivated under intensive (commercial) and semi-intensive (artisanal) production systems. Tilapias are suited to low-technology farming systems. This is because of their fast growth rate, efficient use of natural aquatic foods, propensity to consume a variety of supplementary feeds, omnivorous food habits, resistance to disease and handling, ease of reproduction in captivity and tolerance to wide ranges of environmental conditions; and its use to control aquatic microphytes (Fagbenro, 1998, 2001; Fagbenro and Akinbode, 1988).

**TILAPIA POPULATION CONTROL**

Natural reproduction of cultured tilapia species occurs in one of two ways: mouth brooders or substrate brooders. The ease with which tilapias spawn and produce offspring makes them a good fish to culture. However, this trait creates problems. Survival of young is high and grow-out ponds can become crowded. Fish become stunted as the supply of natural food organisms in the pond is depleted. Fagbenro (2002) reviewed the several effective methods used to control such undesirable tilapia population and the advantages and disadvantages of these control methods were presented, of which very few have progressed from use in experimental studies or development trials to widespread adoption by farmers (Agbebi and Fagbenro, 2006). Where a thorough assessment of user (farmer and consumer) perspectives are considered, the use of local predatory fish species to control such undesirable tilapia recruitment in ponds is one of the most effective and practical methods.

Density control of tilapia populations by predators is not thoroughly researched in Nigeria as only few indigenous predators have been tested. Unlike clariid catfishes, most predators have some drawbacks (Table 2); hence the combined production of tilapia and clariid catfishes has attracted considerable attention, particularly in Nigeria (Fagbenro, 2000, 2004). The hybrid clariid catfishes, *H. longifilis* x *C. gariepinus* and *H. bidorsalis* x *C. gariepinus*, and their reciprocal crosses grow faster than their parental species and have high propensity for piscivory, suggesting that they could be used to control tilapia recruitment in ponds. Choosing an efficient predator of a specific size with a recommended optimum predator-tilapia ratio represents a constraint to the success of this technique. Apart from the proper stocking densities and ratios, the effectiveness of combined culture of tilapias with predators is determined by many interrelated factors: adequate good-quality supplementary feed for tilapias; availability of predator fingerlings for stocking; dietary habits of predator; appropriate time of introduction of predator.

Table 2: Predatory fishes used to control tilapia reproduction in Nigeria.

|  |
| --- |
| Predatory species and their qualities |
| *Clarias isheriensis* (*C. agboinensis*)- prefers tilapia eggs to juvenile tilapia- poor market value due to small adult size- easily propagated in captivity using natural or hormone induced techniques |
| African (sharptooth) mud catfish - *Clarias gariepinus* (*C. lazera*)- omnivorous with high propensity for carnivory- becomes inefficient, competing for food with prey- fast growth, attains large adult size- easily propagated in captivity using natural or hormone induced techniques |
| *Heterobranchus bidorsalis, H. bidorsalis/H. longifilis x Clarias gariepinus*- carnivorous with high propensity for piscivory- fast growth, attains large adult size- easily propagated in captivity using natural or hormone induced techniques |
| Snakehead - *Parachanna obscura*- voracious predator- difficulty in obtaining its seeds in natural waters- inability to reproduce in captivity- attains large size |
| The jewel cichlid - *Hemichromis fasciatus*- voracious predator- a prolific breeder with short generation time (5-6 months)- poor market value due to small adult size |

Source: Fagbenro (2000, 2002, 2004)

Even with the use of predators, the main drawback to tilapia culture remains the excessive recruitment in ponds, which result in low yields of harvestable size. Presently, the use of less expensive and appropriate technology in solving the problem of uncontrolled reproduction in tilapias using biological inhibitory agents is being advocated. Plants with antifertility properties may offer solution as they are easy to obtain and can be incorporated into tilapia feeds. Plants that have been tested and proved for their antifertility properties in Nigeria include *Quassia amara*, *Alloe vera*, *Hibiscus rosa-sinensis*, pawpaw (*Carica papaya*), neem (*Azadirachta indica*) and morinda (*Morinda lucida*) (Raji and Bolarinwa, 1997; Udoh and Kehinde, 1999; Uche-Nwachi *et al*., 2001; Kusemiju *et al*., 2002; Oderinde *et al*., 2002; Adebiyi *et al*., 2002, 2003; Raji *et al*., 2003; Yinusa *et al*., 2005; Jegede, 2010; Ellah, 2011). In Nigeria, extracts of pawpaw seeds, neem leaves, had been investigated as fertility control agents in *O. niloticus*, and *T. zillii* and their contraceptive efficacies in combating the problem of tilapia overpopulation in ponds have been established (Ekanem and Okoronkwo, 2003; Jegede, 2009).

**FEEDSSTUFFS AND FEED/DIETS FOR TILAPIAS**

Both intensive and semi-intensive systems involve input of supplementary and complete feeds, which account for up to 40 and 60% of production costs, respectively (Fagbenro, 1987; Raji, 1998; Fapohunda and Fagbenro, 2006). Two main types of feeds are produced by both sectors namely herbivorous fish (tilapia) feeds, which contain 30-35% crude protein, and carnivorous fish (catfish) feeds, which contain 45-50% crude protein. In 2000, the Nigerian aquaculture industry consumed an estimated 35,570 tonnes of feed (Fagbenro and Adebayo, 2005). The gross ingredient composition used in tilapia feeds follows the least cost formulation presented in Table 3. The various animal by-products and plant residues that have been evaluated in tilapia diets in Nigeria are shown in Table 4.

Table 3. Least cost feedstuffs used for tilapia feed production in Nigeria.

|  |  |
| --- | --- |
|  | g/kg diet |
| Fish meal (65% cp) | 150 |
| Soybean meal (45% cp) | 450 |
| Maize | 250 |
| Fish oil | 40 |
| Vegetable oil | 60 |
| Mineral-vitamin premix | 30 |
| Binder  | 20 |

Source: Fagbenro and Adebayo (2005)

Table 4.Practical feedstuffs used/tested in tilapia diets in Nigeria.

|  |  |  |
| --- | --- | --- |
| Plant residues | Animal by-products | Oils |
| African yam bean meal | Roselle seed meal | Fish meal | Cod liver oil |
| Kidney bean | Kenaf seed meal | Fish silage (dry) | Palm oil |
| Winged bean meal | Mango seeds | Fish silage (moist) | Soybean oil |
| Mucuna seed meal | Cassava peels | Blood meal | Groundnut oil |
| Lima bean meal | Defatted cocoa cake | Shrimp head meal |  |
| Jackbean meal | Cocoa pod husk | Shrimp head silage |  |
| Tamarind seed meal | Maize meal (yellow, white) | Hydrolysed feather meal |  |
| Cottonseed meal | Sorghum | Poultry offal silage |  |
| Palm kernel cake | Acha seeds | Poultry meat meal |  |
| Macadamia presscake | Cassia seed meal | Poultry wastes/manure |  |
| Sunflower seed cake | *Azolla* |  |  |
| Sesame seed meal | Duckweed |  |  |

Source: Jegede (2004), Fagbenro et al. (2003, 2005), Ochang (2007)

**USE OF STUNTED TILAPIAS IN FISH SILAGE PRODUCTION**

According to Akande (1990) and Eyo (1996), low-value freshwater fishes such as tilapias could be economically utilised to produce acceptable high-protein fishery products for human consumption, and fish meal and silage for animal feeds from the processing wastes. Large quantities of cichlids are landed from freshwaters of Africa in short periods and often glut the market, consequently much remain unsold and spoil as a result of poor handling and processing (Shimang 1992). These surplus unmarketable tilapias could be economically recycled for animal feeding, through dry meal rendering or ensilation. The two most important techniques (other than the direct production of rendered dry meals) used to preserve/upgrade the nutritional value are: (a) ensiling through chemical acidification (acid-preserved silage) or microbial fermentation (fermented fish silage), and (b) protein hydrolysis using selected exogenous enzymes (protein hydrolysate). Both procedures rely on producing unfavourable conditions for putrefactive microrganisms, but conducive conditions for proteases (low pH required in the silage; high temperature required in the hydrolysate).

The preparation of acid or fermented silage using tilapias as substrates includes trials made by Akande (1989) and Fagbenro (1994). Fermented silage was prepared from a mixture of minced tilapias (*Oreochromis* spp.), different carbohydrate sources (molasses, corn flour, tapioca flour) and *Lactobacillus plantarum* as inoculum, incubated anaerobically for 30 days at 5-35 oC. The pH and protein solubilization were temperature-dependent (Fagbenro, 1994). The source of carbohydrate did not affect non-protein nitrogen (NPN) content or proximate composition of tilapia silage (Fagbenro, 1994). During storage at 30 oC for 180 days, NPN content increased and there was 8-11% loss of tryptophan (Fagbenro 1994).

**USE OF TILAPIA SILAGE IN FISH DIETS**

Fish silage has been used as a feed supplement for various livestock and poultry animals and results have generally shown that it has good nutritional quality. The biological value of its protein was also comparable with that of fish meal protein. However, only recently has its potential in aquaculture diets been recognised, hence few studies have assessed their suitability. Generally, fish silage has been compared with fish meal and its suitability (or otherwise) assessed by fish growth responses, protein utilization and digestibility. Conflicting results have been reported on fish silage as fish meal replacer (either partially or totally) in fish diets. Moist acid silage has been fed to carps, salmonids, eels, catfish, sea bass and tilapias with satisfactory results but few comparable results are available for fish fed fermented silage. Fagbenro (1994) showed that *O. niloticus* and *C. gariepinus* fed with moist diets containing autolysed protein from fermented tilapia silage stored for 15-60 days showed good growth performance and protein utilization. There were no differences in body (carcass) composition and hepatosomatic index in *C. gariepinus* fed increasing dietary levels of autolysed protein from fermented fish silage and no morphological deformities were observed (Fagbenro, 1994).

Liquid fish silage is viscous, bulky and difficult to transport, stir or store, and can only be fed to pigs directly. There are no solids present to make into presscake; hence water removal by evaporation is necessary. Because of the low solids concentration, it is difficult to dry alone. Several methods of removing the water content of silages include spray drying, vacuum evaporation or drum drying. Alternatively, filler can be added and then dried together, after which the co-dried product can be used as protein supplement for poultry or fish. The nutrient content of the dried product is easily altered by the type and amount of filler material used, such as wheat offal, palm kernel cake, cassava flour, rice bran, maize flour, whey, potato flour, soybean-feather meal mixture, soybean meal, poultry by-product meal, meat and bone meal, feather meal (Akande, 1990; Fagbenro, 1994), the choice of which is determined by cost and local availability. Ayinla and Akande (1988) reported that dietary inclusion of acidulated tilapia silage at 410 g/kg for *C. gariepinus* resulted in a better weight gain than diets containing 40 g/kg fish meal. Fermented tilapia silage co-dried with soybean meal replaced up to 75% of fish meal component in dry diets for *O. niloticus* and *C. gariepinus* while total replacement gave inferior growth responses, feed conversion and protein utilization, caused by reduced palatability of diets or reduced appetite. No differences occurred in the hepatosomatic indices of *O. niloticus* and *C. gariepinus* fed increasing dietary levels of co-dried fermented fish silage: soybean blend and no morphological deformities were observed (Fagbenro, 1994).

**USE OF TILAPIA IN SALTED DRIED MINCED FISH CAKE PRODUCTION**

Stunted tilapias could also be introduced into the human food chain. One of such ways is the conversion to mince and cakes. Fish mince is flesh separated in a communited form from skin, bones, scales and fins of fish. Production of mince from underutilized and unused species is not only an efficient way of recovering flesh for direct human food, but also a wide range of by-products such as pet foods and livestock meal can be made from bones as well as scales, liver, swim bladder, etc. The production of mince from tilapia could be a valuable source for the production of a versatile protein-rich product acceptable to the local consumers. In the production of spiced minced fish cakes from stunted tilapias, Akande (1990) concentrated efforts on producing an inexpensive cake that would be particularly appropriate for the growing fast-food trade as “raw and ready to fry” product. No loss in quality was reported when spiced minced tilapia cake was fried immediately after preparation and assessment of the product varied from good to excellent. An advantage of this product is the convenient preparation and lack of bones, which makes it readily consumed by children. It would be particularly appropriate for the institutional trade as raw, ready to fry product and for the housewife as a ready “heat-in-the-oven” product. Similar works in Nigeria using stunted tilapias as substrates for salted minced fish cakes were conducted by Eyo (1996) and Aluko *et al*.(2000). The cakes produced were stored at ambient temperature (25-32 oC) for up to two months during which the microbial count (total viable count, TVC) reduced from 4.4 x 103 to 1.5 x 102. The drop in TVC was attributed to a lowering of water activity with increasing water loss. Although no attempts were made to identify the organisms in the total plate count, halotolerant organisms were responsible. The results of a taste panel confirmed the flavour as good, without a strong “fishy” taste. Odour, texture, saltiness and colour were satisfactory and no rancid taste was detected.

**USE OF TILAPIA PITUITARY IN CATFISH BREEDING**

African catfishes, *Clarias gariepinus*, *C. anguillaris*, *Heterobranchus bidorsalis*, *H. longifilis*, and their hybrids are cultivated for reasons of their high growth rate, disease resistance and amenability to high density culture, related to their air-breathing habits (Fagbenro *et al*., 1993; Atanda 2007). The genus *Clarias* is circumtropical, constituting a major warmwater aquaculture species in Africa and has been introduced for cultivation in Europe and southern Asia while the genus *Heterobranchus* is endemic to Africa. Clariid catfishes do not breed in ponds; hence artificial propagation using exogenous hormones to induce oocyte maturation, ovulation and spawning is necessary. Various synthetic or purified hormones and steroids have induced ovulation in fishes but their use in Nigeria is limited because they are expensive and are not locally available. To avoid these problems, and to encourage fish breeding programs, the use of crude piscine hypophyses was advocated.

The reluctance of fish farmers to sacrifice precious catfish brooders as donors for hypophyses coupled with seasonality of maturation in clariid catfishes (Ayinla and Nwadukwe, 1988), pose hindrances to homoplastic hypophysation in Nigeria. Although pituitary extracts from non-piscine sources such as African bullfrog (*Rana adspersa*), common toad (*Bufo regularis*) and domestic chicken (*Gallus domestica*) have also induced spawning in clariid catfishes in Nigeria, (Fagbenro *et al*., 1992; Nwadukwe, 1993; Inyang and Hettiarachchi, 1994; Salami *et al*., 1994), the standardization of methods dosages and concentration of hormones are often inadequate. It is generally more efficient to induce ovulation in fishes with a pituitary gland extract or a gonadotropin from a teleostean source because of the phylogenetic closeness between the donor and the recipient.

Sexually-mature tilapias are available all-rear round and could be used as alternative sources of piscine hypophyses for catfish breeding. Salami *et al*.(1997) investigated the effectiveness and dosage of acetone-dried pituitary extracts from tilapias (ADTPE) to induce oocyte maturation, ovulation and spawning in *C. gariepinus* and *H. bidorsalis*. Results showed that oocyte maturation and ovulation were induced in female *C. gariepinus* and *H. bidorsalis* by single intramuscular injection of 6-10 mg.kg-1 ADTPE with optimum results obtained with 8 mg.kg-1 acetone-dried tilapia pituitary extracts in both catfishes. At ambient temperature (27oC), ovulation occurred within 14-18 hours post-injection resulting in 16-20% increase in egg diameter. Fertilization and hatching percentages increased with increasing hormone dosage. Salami *et al*.(1997) demonstrated that optimal egg and larval quality in *C. gariepinus* and *H. bidorsalis* could also be achieved by using the tilapine pituitary hormone extracts to induce ovulation. The efficacy of ADTPE precludes the depletion of mature catfish (potential brooders) traditionally sacrificed for collection of hypophyses in fish hatcheries.

**USE OF TILAPIA: CEREAL BLENDS IN HUMAN NUTRITION**

Cereal grains – maize, rice, and sorghum are the staple food of people in the tropics and provide about 75% of total calorie intake and 67% of total protein (Inhekoronye and Ngoddy, 1985). Root and tuber crops (cassava, yams, cocoyams, sweet potatoes) rank next in importance in providing the major part of the daily energy needs of people in the tropics (Inhekoronye and Ngoddy, 1985). Cereal grains as well as root and tuber crops therefore provide the main dietary items for many people, resulting in food with low nutritional value as they are not adequate source of micro and macro nutrients (Brown, 1991). Efforts made to improve the nutritional value of these staples especially cereals in the past were based on fortification with legumes to boost the deficient amino acids, (Bressani and Eliaz, 1983; Egounlety and Syarief, 1992; Salami, 1988). Deficient amino acids in cassava tuber are methionine, lysine, tryptophan, phenylalanine and tyrosine while in cereals they are – lysine and tryptophan. Protein quality is therefore synergistically improved in cereal-legume blends because of the lysine contributed by the legume and methionine contributed by the cereal (Bressani, 1993), but according to Okeiyi and Futrell (1983), the resulting improved diets are of variable organoleptic properties and poor digestibility, these were attributed to the low solubility of plant protein.

Fasasi *et al.(*2005, 2006, 2007) however replaced the legume (plant protein) in cereal – legume diet with the underutilized tilapias (animal protein), with the aim of reducing the post harvest losses incurred especially in developing countries, and resultant production of highly digestible novel food which will enhance optimal utilization of these worldwide cultured species of fish. Considering the potentials of “Cereal-fish flour” mixes, investigations were made into the properties - physicochemical, and storage stability studies so as to establish the characteristics which may affect its behaviour in food systems during processing and storage hence its usefulness and acceptability for industrial and consumption purposes.

**CONCLUSIONS**

African aquaculture research and development are producing promising results, despite the economic difficulties under which much of these are undertaken. The future of tilapia farming remains bright, despite the somewhat disappointing recent statistics. In Nigeria, wherever inland aquaculture flourishes, tilapias are likely to be a major, if not the major farmed fish commodity. This can be true if research is better directed towards farmers’ needs; if better breeds and farming systems are developed together; if anti-tilapia attitudes are changed where they are ill-founded; and if tilapia farming becomes a more sustainable and environmentally compatible enterprise, well-integrated with other development initiatives.

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