TILAPIA FARMING IN HUNGARY WITH THE USE OF GEOTHERMICAL WATER SUPPLY

László Szathmári[1], Ferenc Radics, Barna Fodor[2], Katalin Dankó[3]

[1]University of West Hungary, Faculty of Agriculture and Food Sciences
H-9200 Mosonmagyaróvár, Vár 4

[2]SZARVAS - FISH Kft. H-5540 Szarvas, I. külterület 57

[3]ARNYKARASZ Bt. H-5540 Szarvas, Jokai u. 40/B

Introduction

Despite of the long history of Hungarian aquaculture the main fish farms were established in the last century. Carp dominated farming systems ensuring the alive fish demand of the market. The fish consumption was low (2.5 kg/capita/year), seasonal and related to religious feasts. The prices followed the seasonal production. In the 90's structrual changes in food industry – including the fisheries sector – faced new challenges. As the new generation turned towards ready-to-cook products, the demand for alive fish reduced significantly. The increased import and changes in consumers' habits resulted to a decreased interest in carps, while others, mainly farm raised species such as African catfish and trout – presented signifcant growth in sales.

Updated fish products possess the following criteria:

- white or pink colour
- firm texture
- slight flavour and odour
- free of fish bones
- standard sizes
- continuous supply and quality all over the year
- ability to bio-production

The tilapia meets these qualifications. Farming of the fish is justified, because it can be raised in polyculture with carps and with a low content of animal protein in food. The worldwide boom in production, as well as the Hungarian experiences in aquaculture supported the introduction of tilapia farming in the country. First trials had been executed by the Research Institute for Fisheries, Aquaculture and Irrigation Szarvas and Szarvas-Fish Ltd.

Hungary is rich in thermal spring water sources. Geothermical gradient is uniquely high in the lowland (20 m/^{o}C). There are more than 1300 springs in operation ensuring warm water of 35-93^{o}C. The Szarvas-Fish Ltd. works in fish farms using geothermical water supply. The Tuka Unit produces African catfish primarily, but tilapia raising also takes place at the site. The domestic market is supplied by this farm. Volume of production is still low, therefore the technology has been elaborated to local conditions with some extensive elements in it (propagation).

The farm is situated in the less developed region of Hungary, ensuring labour possibilities for the inhabitants of the surrounding villages. The new HACCP operated fish processing plant, which produces fresh gutted and filletted goods, also takes part in the rural development offering further chances to decrease the unemployment of the region.

Presentation of farming circumstances

The farm is settled in the oriental part of Hungary (Hajdú-Bihar county) along the middle stage of river Tisza. Five wells ensure the water requirement of the plant. One gives 19°C water, and four of them give 26-27°C water.

According to requirements, two mixer-aerating units ensure 21-27°C water for the raising tanks.

The water supply for tilapia production shares 150-200 l/min with the following parameters:

Water temperature:	23-25°C
pH:	7.7-8.0
Conductivity:	816 µs/m
HCO_3:	545 mg/l
KOI:	8.2
NO_3:	1.5 mg/l
NH_4:	0.3 mg/l

The required dissolved oxygen content (95% saturation) is ensured by aeration systems. There are paddle wheels in mixer and propeller tipe aerators in rearing tanks. The power supply of one tank (2 aerators) is 0.6 kw/h.

Materials and methods

During the elaboration of raising techniques of Nile tilapia under domestic conditions the elements of propagation, tank management and feeding were emphasized.

Due to local circumstances, propagation was performed by natural group spawning. Following the harvesting of fingerlings, feeding examinations were executed concerning daily feeding rate, frequency of feeding as well as digestible protein content of the food.

Stocking material in the experiments were figerlings of Chitralada parent stock of Nile tilapia (*Oreochromi niloticus L).*

The propagation method was group spawning in outdoor ponds. This is the most simple and economic way of fingerling production. The spawning season ranged from June to August. These experiments began in 2001.

After the appearance of fingerlings in ponds, despite of the rich plankton stock, we applied *ad libitum* complementary feeding with the use of catfish food (50% digestible protein, 300-500 μm size). In September, following the removal of macrovegetation, we harvested the ponds by methods of carp fingerling catching. Fingerlings showed various sizes, and following to separation and treatment against parasites, they were suitable for intensive farming.

We stocked the fingerling into tanks of 100-200 m^3 in a density of 80-100 individuals/m^3 (30-40 g size). Sex reversal was not necessary as spawning under dark conditions was not observed, due to delayed maturation. This is a comparative advantage of indoor raising. In the future we plan to execute investigations concerning the growth rate of different sexes. By the end of the raising period (6-7 months) 300-350 g size fish could be obtained. The survival rate was more than 97%. Growth was tested fortnightly in order to calculate the food rate for the following period. In the begining the feeding rate was 4% of the total weight in tank, which reduced continuously to 2% by the end of raising. The extruded 3-5 mm size tilapia food contained 29% of crude protein and 7% of fat. During the formulation of diet we adapted the results of our former investigations. The feeding was executed by proportioner type self-feeders.

In the fifth month of culture market sized were separated. The tilapia were sold fresh (on ice) cleaned and gutted in a quantity of 200-300 kg/week. It was observed that consumers did not prefer frozen tilapia products. Sales of iced products grow continuously, thus we plan to produce fresh fillets as well.

Results and discussion

The 1st trial of group spawnings were executed in two ponds of 400 m^3 (300 m^2). One hundered and ten breeders were stocked into one pond in the end of July and begining of August. The sex ratio were 1:1 and 4:1 (♀:♂).

The harvesting was performed during the first half of September. Each pond contained 35,000-38,000 individual fingerlings.

Due to variant nursing periods a difference was marked in fingerling sizes. In the case of the 1st pond (44 days) the size was 1-6 cm, while the 2nd pond (29 days) had 2.0-2.5 cm fingerlings.

In the 2nd spawning trial (spawning tank 3) the stocking rate was 650 breeders (900 g average size) at a sex ratio of 1:1(♀:♂). Fish were fed 1%/weight/day using food with 36% crude protein content. First fingerlings were observed in 14 days following stocking. In this period we observed 5-6 spawnings. The harvesting resulted to 85,000 fingerlings in sizes between 3.0 and 12.0 cm. Results are shown in Table 1.

Table 1. Results of group spawning of Nile tilapia.

	Spawning tank 1	Spawning tank 2	Spawning tank 3
Date of stocking	1-2nd Aug 2001	21-22nd Aug 2001	29th July 2001
Number of breeders	110	110	650
Sex ratio ♀:♂	1:1	4:1	1:1
Date of harvesting	8-10th Sept	8-10th Sept	11th Sept
Harvested pcs	36 000	38 000	85 000
Harvested sizes	1,0-6,0 cm	2,0-2,5 cm	3,0-12,0 cm

In order to increase the volume of production, and to ensure the yearly fish supply, we plan to develop the technology of reproduction and intend to import red Nile and blue tilapia.

Determination of feeding rate using a given food formula

We investigated the effect of feeding intensity on growth in a 25-day trial period in three replications. Fish were raised in boxes settled in plastic troughs under continuous water flow. Groups contained 20 individuals and were fed in a daily rate of 2%, 4%, 6%, 8%, 10% depending on body weight. The crude protein was 36% in each diet. Feeding happened during daytime in five equal periods. The correction to quantity was executed every 5 days.

The effect of average daily feeding intensity on growth was expressed by the specific daily weight gain as well as the food convertion ratio. The changes in the three parameters are shown in Figure 1.

During the trial period experimental groups reached 6-15 g average body weight, which means a growth of 30-320%. The SFR, SGR and FCR values are the following:

Optimal food dose: $SFR_{opt.}$ = 4.98%/day
Growth at optimal food dose: $SGR_{opt.}$ = 3.21%/day
Food Convertation Ratio at optimal food dose: FCR_{opt} = 1.55 g/g
Maximum food dose: $SFR_{max.}$ = 8.25%/day
Growth at maximal food dose: $SGR_{max.}$ = 4.03%/day
Food Convertation Ratio at maximal food dose: $FCR_{max.}$ = 2.08 g/g

During the culture period, the optimal food dose decreased continuously to 2%.

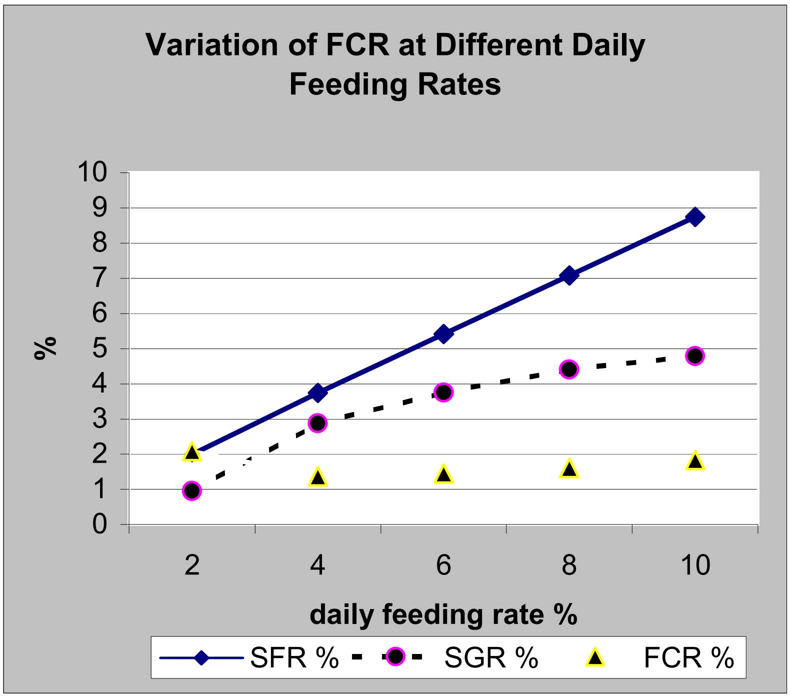

Figure 1. Variation of FCR at different daily feeding rates.

Influence of feeding frequency

In further experiments the effect of feeding frequency on FCR and SGR were investigated. Eight fingerling groups were formed in sizes between 5.00 and 5.22 g/ind using random selection (18 ind/group). Groups were raised in boxes of 36x28x9 cm in 9 liters of water.

Daily food doses were distributed once and in several times (3, 5, 7 parts) from 8 am to 2 pm. Four trials were made in two replicates. During the 20-day period the total weight was measured every five days and the food doses were corrected. Experimental data are demonstrated in Table 2.

Table 2. Coherence among feeding frequency, FCR and SGR in the rearing of tilapia fingerlings.

Tank No.	Feeding frequency Feedings/day	W_0 (g)	W_{20} (g)	DW (g)	F (g)	FCR (kg/kg)	SGR (%)
1	1	90	196	106	101.30	0.96	3.89
2	3	91	256	165	117.34	0.71	5.17
3	5	94	259	165	117.43	0.71	5.07
4	7	94	256	162	120.00	0.74	5.01
5	1	90	209	119	101.99	0.86	4.21
6	3	93	245	152	113.58	0.75	4.84
7	5	94	254	160	113.76	0.71	4.97
8	7	91	255	164	113.66	0.69	5.15

It was pointed out that the modification of feeding frequency shows strong influence on growth, FCR and SGR. Observed data confirm those theories, in which the elaboration of feeding technologies have to consider technical solutions in which the feeding is frequent in small doses. In the case of hand feeding it is reasonable to increase the number of daily distribution. Feeding efficiency increased significantly by the change of rationing from 1 to 3 per day. In the case of more frequent dosages the results showed more steady values. Frequent feeding with smaller doses resulted to balanced water quality as well. Because of this, under practical conditions we fill self-feeders twice a day according to the actual total fish weight of the tank. Use of proportioner feeders ensure the distribution of food in small doses.

Optimalization of crude protein content during the raising of tilapia fingerlings

Crude protein content of diet influenced significantly the feeding efficiency. Results are demonstrated in Table 3 and Figures 2 and 3.

Table 3. Effect of crude protein content of food on feeding indicators.

Crude protein %	FCR	SGR%
31	1.04	4.25
35	0.96	4.50
39	0.98	4.49
43	0.95	4.63
47	0.97	4.50

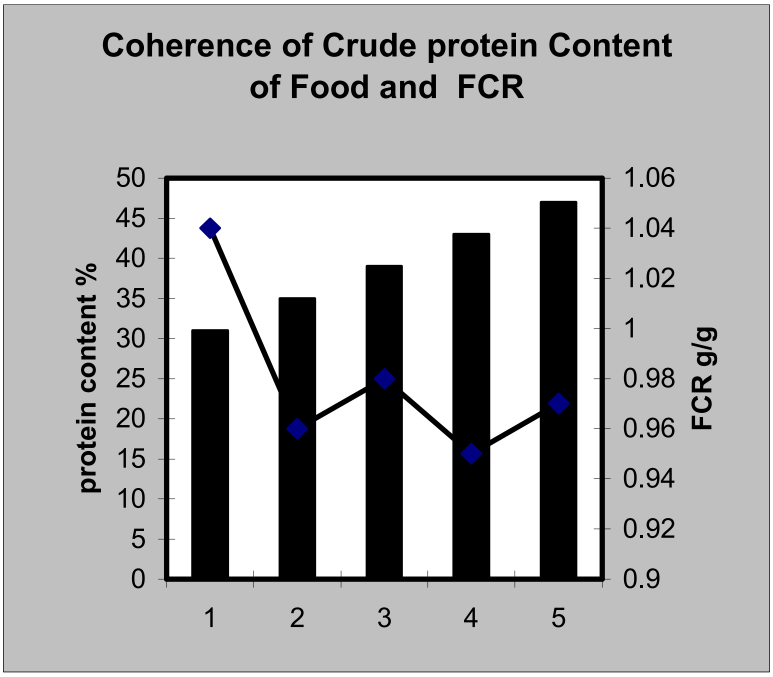

Figure 2. Coherence of crude protein content of food and FCR.

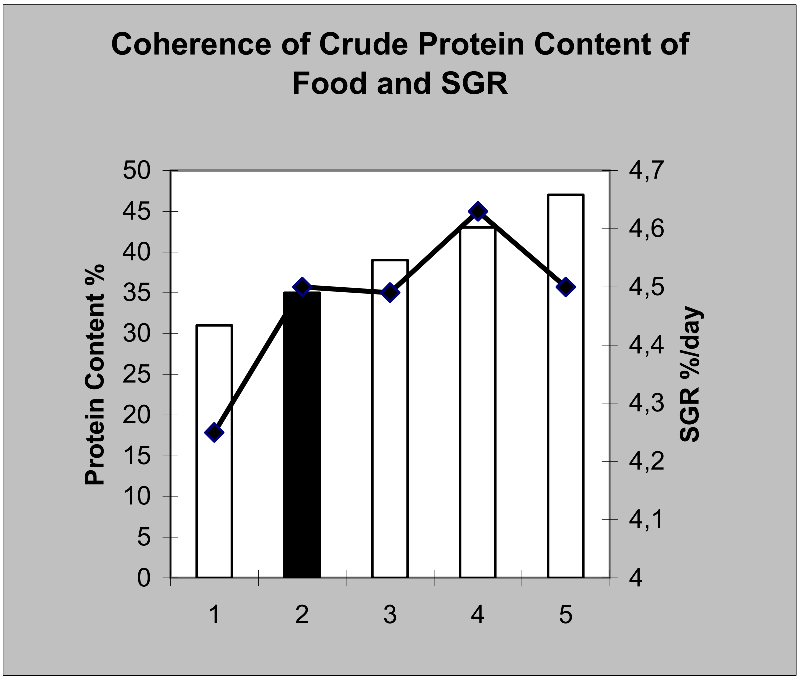

Figure 3. Coherence of crude protein content of food and SGR.

Profitability of aquaculture strongly depends on FCR values, whereas 55-60% of the production costs are derived from feeding. As it is shown on Figure 3, the best growth rate was observed in the case of feeding pelleted diet containing 43% of crude protein. During the trial using *ad libitum* feeding, the effective feeding rate was 4.3-4.4% of the total body weight.

Regarding the feeding costs it can be stated that the specific price of low protein content diets compensates the low feeding indicators. Thus parallel to growth of fingerlings, in farm raising we turned to use food formula containing 29% of crude protein. Table 4 presents the composition of food formulas applied in the investigations.

Table 4. Components of different tilapia food formula.

Components (%)	Diet formula				
	1 31%	2 35%	3 39%	4 43%	5 47%
Fish meal	6	8	15	24	30
Meat meal	22	28	30	28	30
Blood	5	5	5	5	5
Extruded soybean	10	10	10	10	10
Wheat	53	45	36	29	21
Vegetable oil	2	2	2	2	2
Minerals	1	1	1	1	1
Vitamins	1	1	1	1	1
Total (%)	100	100	100	100	100
Crude protein (%)	30.81	34.65	39.16	42.81	46.81

Recent rules do not restrict the use of animal proteins in fish diets, therefore it will be essential to formulate new diets with the use of herbal proteins. Fortunately, the tilapia accepts more of this source than other farmed species.

The results of tilapia raising under farm conditions can be seen in Table 5.

During the culture, fingerlings (40-100 g) reached the minimum market size (300 g) in 3-6 months. FCR varied from 1.57-1.80 kg/kg. In 2002-2003, annual production of the farm was 12.5 tons of market sized tilapia. The grading of fish was performed only during harvest and preparation of the fish for processing. The smaller fish were restocked for additional rearing.

The market survey indicates that a strong interest is expected in bigger fillet size of tilapia, therefore the culture has to produce 500-700 g fish. In this case the increased FCR will affect the production cost, but sales prices of first quality product will compensate the extra input.

Table 5. Results of tilapia culture at farm conditions.

	Stockings			Harvestings				Survival rate	Food Quantity	FCR
Date	W_0 (kg)	n_0 (db)	w_0 (g/db)	Date	W_0 (kg)	n_0 (db)	w_0 (g/db)	%	kg	kg/kg
21st Sept. 2001	339	8350	41	18th Apr. 2002	2654	8116	327	97.20	3629	1.57
11th Oct. 2002	897	15402	58	11th Feb. 2003	2716	14967	181	97.17	3276	1.80
11th Oct. 2002	945	5762	164	11th Feb. 2003	2202	5728	384	9941	2119	1.69

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