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Why grow fish for food in developing countries?

A popular argument against feeding concentrated food materials to animals instead of feeding to humans directly is that only 10 to 30 per cent of the energy of protein fed to animals is recovered as human food. A greater handicap for fish is the fact that they must be cultured in an aquatic environment and they are extremely perishable after they are removed from the culture system. So, to advocate that growing fish for food will help ease the world's food problems, some good arguments must be available.

Fish culture can improve man's nutritional status in developing countries by two methods: indirectly by providing a high-value product for export or high income markets, thus, sustaining a viable industry; or directly, as a product for domestic consumption.

The most excitement at the present time in the development of fish culture in these countries may very well be in producing fish for an export market. Many of the developing countries have the climate, location and other resources for extensive production of various kinds of fish, but the cost of production is prohibitively great for the fish to be purchased by much of the local population. Thus, the fish are exported to the countries where consumer purchasing power is greater. In this manner, fish culture

may develop into a profitable industry and consequently improve the economic status of the people associated with it and give them the opportunity to improve their diets.

Good examples of fish culture developing for export markets are apparent in the Pacific area. Japan is a good consumer market for fishery products but does not have resources as favorable for extensive fish culture as other countries in the Pacific. Therefore, several countries with warm climates, much brackish water, labor and other resources are developing fish farming industries to supply Japanese markets. Milkfish (Chanos chanos) culture in the Philippines is rapidly developing into an extensive industry and its continued growth will be related to a large degree to the favorable export market. Marine and freshwater prawn culture in Thailand is being supported vigorously by the local government with the stimulus of attractive demand and prices from Japan. While favorable export markets may be the most attractive incentive to initial investment in many fish culture operations, significant contribution to local food supplies also is feasible. Aquaculture, in fact, has been demonstrated to be even more profitable through innovative techniques such as polyculture of two or more species to produce a primary product for the export market while rearing secondary species for local consumption. In Taiwan, eels produced in intensively fed freshwater ponds are shipped to Japan and Europe, while carps economically produced in the same ponds as a by-product are utilized locally. Catfish are cultured in Honduras for export to the United States and Europe, while tilapias reared in combination with the catfish are marketed within the country.

If fish is to make a direct contribution to the nutritional status of people in a developing country, i.e., be consumed locally, it must be available within the economic means of a significant portion of the population to buy it. No matter how valuable fish is nutritionally, if people are not able or willing to buy it, it will contribute nothing in this respect. People in developing, or even in the developed countries buy fish for sensory and economic reasons and nutritional value is of minor importance. They will buy fish because it is competitively priced with other animal foods, or as in some areas they appreciate fish enough to pay a higher price for it than for other foods of animal origin. In most societies, even though the purchasing power of the people is low, they will pay a relatively high price for animal foods because they desire to have it in their meals. The President's Panel on the World Food Supply (1967) reported that the prestigeous image of animal foods in the diets of people worldwide was so deeply ingrained that it would probably be easier to increase the availability of animal foods than to change the food preferences of the people. Hence, the proposition of replacing animal foods with plant foods, which would be appreciably more economical, is probably impractical in developing countries.

In table 1, a comparison is presented of prices of fish with other animal foods in several countries. This may be used as a general index of the maximum price that the consumer will pay for fish in that area. In some countries, people will pay more for a popular fish than for other animal foods, while in others fish must be considerably cheaper than meat of poultry for local consumption.

Table 1. Comparative prices of fish, meat and poultry in various countries, 1972 - 1973[1]

Country	Animal	Price per kg (U.S. dollars)
Thailand	Clarias species catfish	.50
	Freshwater prawn	1.50 - 2.00
	Marine prawn	.50 - 1.00
	Pork	1.25
	Beef	1.00
	Poultry	.75
Philippines	Milkfish	.67
	Clarias species catfish	.50
	Marine prawn	1.00 - 3.00
	Pork	1.00
	Beef	1.10
	Poultry	.75
Costa Rica	Corvina	.37
	Dorado	.30
	Marine prawn	.45
	Pork	.68
	Beef	.75
	Poultry	.42
Nepal	Common carp	.80
	Poultry	.50

[1] Sources: Markets in Thailand, Philippines, Costa Rica and Nepal. Obtained by survey teams from International Center for Aquaculture, Auburn University.

Thus, an important factor in determining whether or not cultured fish make a significant contribution to the diet of local people in developing countries is the economic aspect of conversion of food materials to fish flesh. An argument favoring the role of animal foods, which was presented by the President's Panel on World Food Supply, was that animals can utilize by-products or feedstuffs unsuitable for human consumption. The use of grains, oil seeds, or other materials that humans compete for is usually based on economics; if grains are in abundance and of low cost, they are put into animal feeds. If grains are in great demand for human food, more crude materials are converted into animal flesh. Ruminants, which can utilize fibrous plant tissue, are more popular food animals in areas where grains are valuable for human foods. As long as fish can be produced from foods that are unsuitable for the human diet, fish culture will probably be feasible.

It is quite improbable that feeds such as those fed to catfish and trout in the U.S. could be used in developing countries unless the fish were to be grown for a lucrative export market. Often foreign students who come to Auburn or other institutions in the U.S. to study fish culture observe these high quality feeds being used and, upon returning to their country, try to develop a fish culture program based upon using similar types of fish food. The systems of fish culture which have the greatest potential for providing fish for consumption in the developing countries are probably those involving fish which can efficiently convert natural aquatic foods and/or crude terrestrial feedstuffs into fish flesh.

Table 2 shows the various classes of food for cultured fish. Natural aquatic foods, which may be enhanced by fertilization, are generally the

Table 2. Classes of foods for cultured fish

Class	Examples
Natural Aquatic Foods:	
Micro	Zooplankton and phytoplankton, benthic organisms
Macro	Crustaceans, insects, larvae, prey fish
Supplemental Feeds:	
Concentrates	Grains, oilseed meals, fishmeal
Roughages	Grass or foliage (fresh, dry), seed hulls, stems
By-products	Rice brans or polishing, wheat milling by-products, spoiled or condemned grains, trash fish

most economical, but without supplementation they produce only moderate yields with most fish. Concentrates are the most expensive but have high nutritive value and are used primarily in intensive production of high value fish such as trout, catfish and prawns. Roughages have low nutritional value and are inefficiently converted into weight gain, even by the "herbivorous" fishes. By-products are usually the most practical supplemental feeds, and fish culture systems which take maximum advantage of natural foods supplemented with economical by-product feeds are likely to be the most suitable for producing fish for food for developing countries.

Table 3 gives examples of popular food fishes and types of foods they utilize. The carp is an efficient feeder on pond bottom organisms and will eat a variety of supplemental feeds. Tilapias can feed at elementary levels of the aquatic food chain and also respond favorably to supplemental feeds. Milkfish (Chanos chanos) are exceptional converters of planktonic and benthic organisms to weight gain, but do not accept "artificial" feeds well.

Culture of the Clarias species (batrachus and macrocephalus presents an excellent example of the conversion of by-product feeds to edible flesh. The fishes are desirable types of intensive culture because they can survive low dissolved oxygen conditions when grown in heavy concentration. The principal feed used consists of 10% broken rice, 40% rice polishings and 50% trash fish, all of which are not marketable for human food. This provides a reasonably well-balanced diet, has good feeding properties when heated and ground and does not need to be pelleted, and provides a conversion ratio of 2 pounds of dry feed to a pound of weight gain.

Table 3. Types of Foods Utilized by Various Kinds of Cultured Fish

Fish	Type of Food	Yield per Crop kg/ha	Conversion kg dry feed/kg gain
Common carp [1]	Natural food: bottom zoo- organisms micro- and macro- size	800	-
	Supplemented with low quality grain	2,100	3-4
	Supplemented with high protein feed and increased stocking density	4,000	1.5
Tilapia [1,2,3]	Natural food: decaying organic matter, bottom organisms, plankton, algae, higher plants	500-1,400	-
	Supplemented with leaves or grass	-	20.0
	Supplemented with grain	-	6.0
	Supplemented with high protein feed	4,400	0.7
Milkfish [4]	Natural food: benthos, plankton	1,500	-
	Supplemental feed: poor response		
Clarias species catfish[5]	Natural food: negligible because of high stocking density		
	Supplemental feed: 1/3 broken rice, 1/3 rice bran, 1/3 trash fish (dry basis)	53,800	2.0
Channel catfish[6]	Natural food: large zoo-organisms		
	Supplemental feed: high protein concentrated feed	3,000	1.3

[1]Source: "Fish Nutrition", pp. 578 - 605. Academic Press, New York, 1972.
[2]Source: "Proceedings of the World Symposium on Warm-Water Fish Culture", pp. 237 - 242, FAO Fisheries Report 44, Vol. 4: IV/E-14, Rome, Italy, 1966.
[3]Source: Swingle, H.S. 1960. Comparative evaluation of two Tilapias as pondfishes in Alabama. Trans. Am. Fish. Soc. 89(2): 142 - 148.
[4]Source: "Inland Fisheries Project Annual Technical Report", National Science Development Board Project No. 2235, Republic of the Philippines, 1972.
[5]Source: Personal communication with fish farmers near Bangkok, Thailand, 1972.
[6]Source: Personal Observations.

When compared to other animal foods, fish offers the following advantages in the developing countries:

1) People desire fish in their meals over, or on equal basis to, meat and poultry;

2) Fish can produce more protein from a pound of feed than land animals; however, if the protein level in fish feeds is scaled down to a level comparable with that in livestock feeds, the rate of protein synthesis would be near the same, as indicated in Table 4;

3) Fish can utilize food or feeds that land animals don't, especially natural foods in the aquatic environment;

4) Fish can utilize resources that land animals can't, such as water resources in estuaries, swamps, irrigation canals, rice fields;

5) Through polyculture, combinations of species of fish feeding at different levels of the food chain may be stocked so that the total yield of the system is increased significantly.

Other advantages that fish have with or over other animal foods are nutritional. Although the consumer will choose fish for other reasons, the nutritional values of fish are an important reason for the development of programs to emphasize fish as a food for people in the developing countries. The President's Panel on World Food Supply reported that 60% of the world's population received inadequate nutrition, and protein and calories were the primary deficiency. Protein deficiencies are particularly more acute in areas where single foods provide most of the nourishment, such as in rice-

Table 4. Conversion of practical productive ration and protein to weight gain by fish, poultry, swine and cattle

Food animal	Per cent protein in ration	Conversion	
		kg ration/kg gain	kg protein/kg gain
Fish	32	1.3	.41
	40	1.0	.40
Poultry	18	2.0	.36
Swine	15	3.0	.45
Cattle	11	6.8	.78

eating areas. Protein deficiency may cause abnormal physical and mental development, and increased susceptibility to infectious diseases. In adults it may retard socio-economic and cultural development by making the person lethargic and rebellious.

In table 5 the essential amino acid profile of fish, red meat and a cereal grain, rice is shown. Fish is the best source of lysine of all animal flesh and lysine is the most limiting amino acid in cereal proteins. Hence, fish is an excellent supplement to cereals.

The nutritional score of fish is slightly above that of red meat, but both are much higher than the score for plant proteins (Table 6).

The fat in fish is more unsaturated than that in the flesh of red meat animals (Table 7), although not all nutritionists will agree that this is a health advantage to humans. However, the omega-6 or linoleic series fatty acids which are essential in the diet of man are higher in fish fat than in hard animal fats.

A gram of moisture-free fish flesh contains approximately 4.75 kilocalories of energy as compared to 6.00 kilocalories in beef which has more fat. Conversely, 1.0 g of moisture-free fish contains 0.85 g of protein compared to 0.4 to 0.5 g of protein from red meat (Table 8). Fish is a concentrated source of high quality protein.

The mineral contribution of animal foods is essential for proper growth and development. All-plant diets are especially deficient in respiratory (Fe, Cu, Co) and structural (Ca, P) minerals.

Table 5. Amino Acid Composition of Channel Catfish, Beef and Rice

Amino Acid	Per cent of protein		
	Catfish	Beef	Rice
Arginine	6.3	6.1	8.8
Histidine	2.8	3.6	2.3
Isoleucine	4.3	5.0	4.4
Leucine	9.5	7.8	8.6
Lysine	10.5	8.7	2.8
Methionine	1.4	2.7	1.4
Phenylalanine	4.8	3.8	4.8
Threonine	4.8	4.5	3.6
Valine	4.7	5.2	6.4
Tryptophan	0.8	1.0	0.1
Total essential	49.9	48.4	43.2
Nonessential	50.1	51.6	56.8

Table 6. Net protein utilization (NPU) values of selected food proteins[1]

Food	NPU (Egg = 100)	Limiting Amino Acids
Fish muscle	83	Tryptophan
Beef muscle	80	Methionine + cystine
Rice	57	Lysine
Corn meal	55	Lysine + tryptophan
Soy flour	56	Methionine + cystine
Navy beans	47	Methionine + cystine

[1]Source: "Protein Requirements" WHO Technical Reports Series No. 301, 1965. World Health Organization, Geneva, p. 48.

Table 7. Fat in Fish Flesh

Item	Per cent fat in wet flesh	Per cent saturated	Per cent unsaturated
Shrimp	0.5	27	73
Flounder	2.0	28	72
Channel catfish	4.2	30	70
Red meats	15-30	48	52

Table 8. Protein and Caloric Values of Fish Flesh

Item	Per gram of moisture-free flesh	
	Grams protein	Kcal. energy[1]
Shrimp	.88	4.08
Flounder	.80	4.68
Channel catfish	.79	4.75
Red meats	.40 - 50	6.00

[1]Caloric value of flesh calculated on basis of protein = 4.0 kcal. per gram and fat = 9.0 kcal. per gram.

So, in response to the question initially proposed regarding the merits of culturing fish for improving human nutritional status in the developing countries, the following points have been discussed:

1) Fish culture may develop into a profitable export industry and consequently upgrade the economic status of affected persons and allow them to improve the quality of their diets;

2) Fish, as other animal foods, is highly desirable in man's diet;

3) With proper selection of species, culture system and food sources, fish can be produced economically enough for persons in most societies to afford it in their meals;

4) Fish is a concentrated source of protein and is an excellent nutritional supplement to cereals.

References

Panel on the World Food Supply. 1967. The World Food Supply, A report of the President's Science Advisory Committee. 711 p.

Figure 1. Eels, which are intensively cultured in Japan, require precisely formulated, concentrated feeds. Other fish, such as channel catfish and trout in the United States, having similar, expensive feed requirements necessarily have high market value.

Figure 2. Tilapia are efficient converters of a variety of natural and supplemental foods to fish flesh which makes them desirable species for low cost production. Use of hybrid males, as shown above, produced from T. aurea and T. hornorum, prevents extensive reproduction in culture ponds and allows for production of desirable size fish.

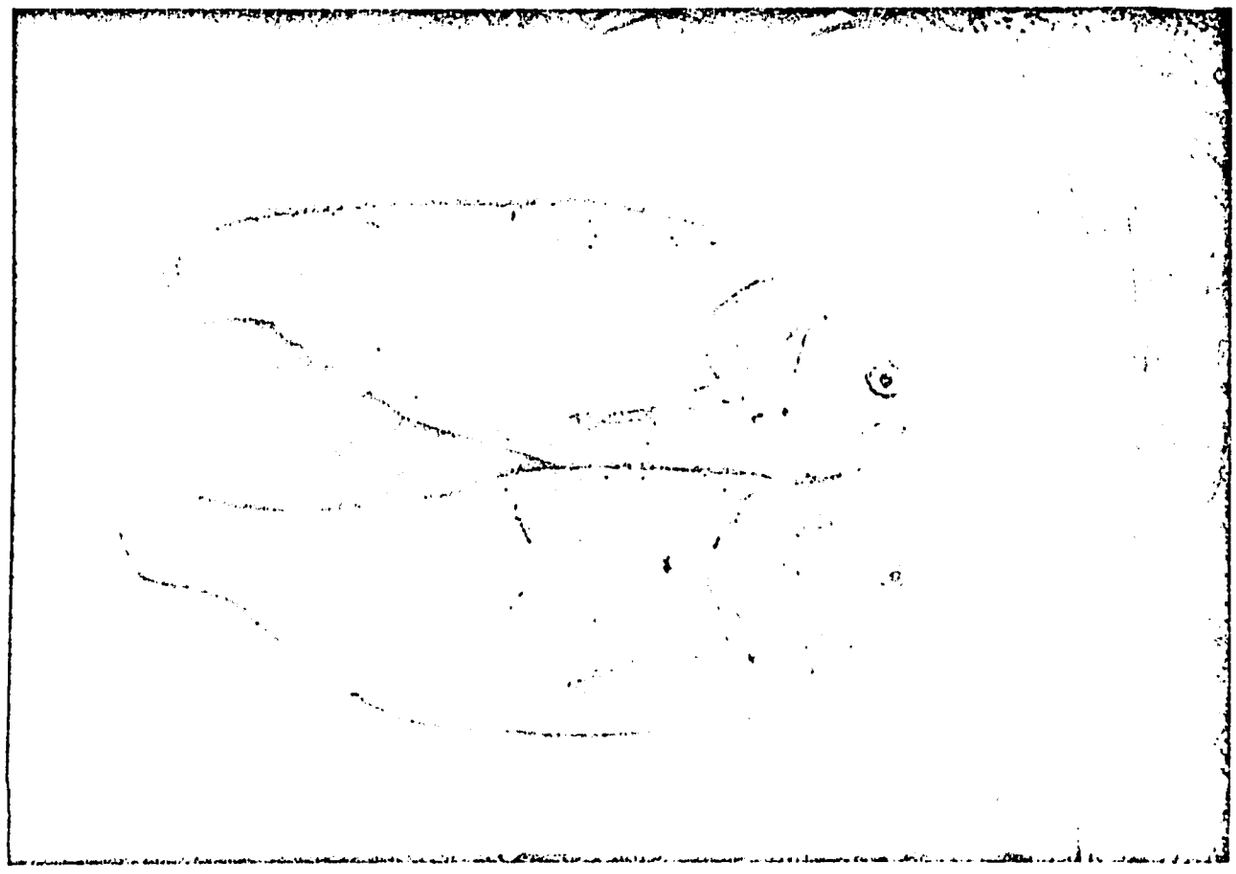

Figure 3. Culture of Clarias species of catfish in Thailand presents a good example of the use of by-products for an adequate but low cost feed for intensively cultured fish. The moist feed is prepared from rice bran, broken rice and trash fish.

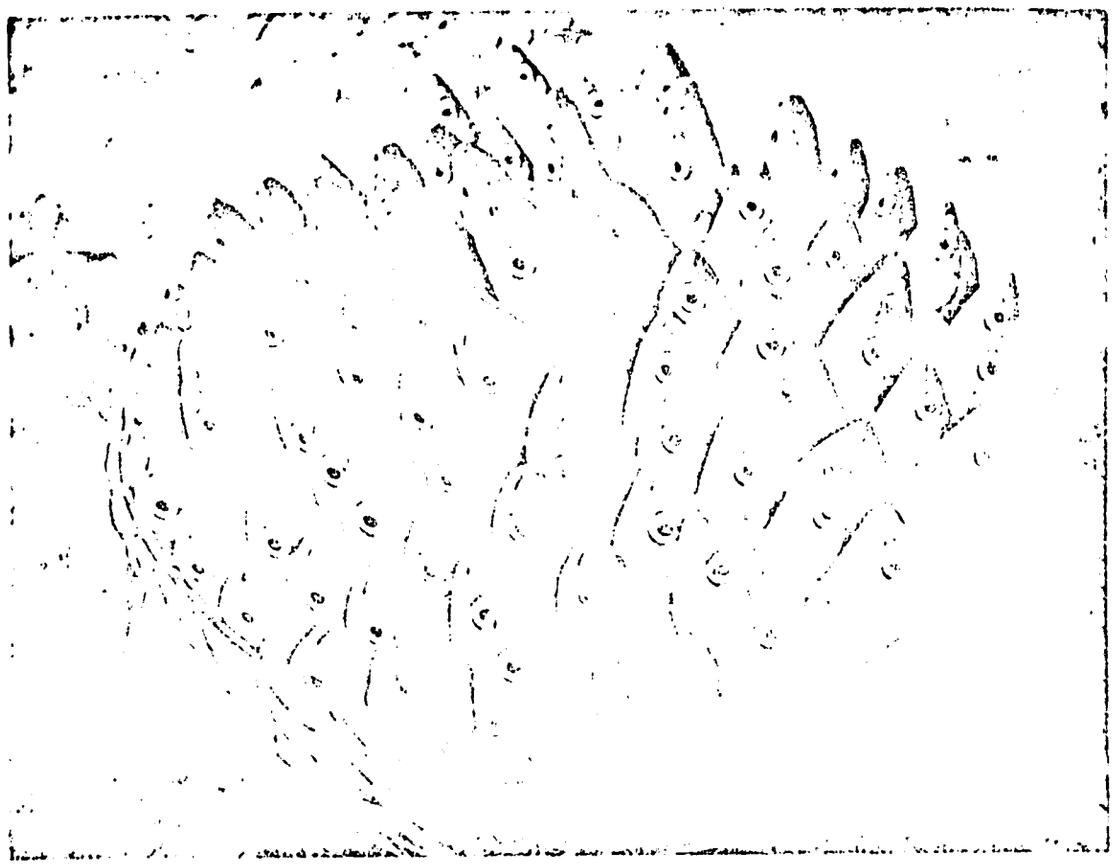

Figure 4. Milkfish (Chanos chanos), cultured extensively for food in Southeast Asia, do not accept artificial feeds readily but make excellent gains from plankton and benthic organisms.