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An Economic Analysis of Producing Surimi from Catfish Byproducts

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Use of trade names in this manuscript is for identification of a particular technology and neither constitutes endorsement of these products nor implies discrimination against similar products.

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Introduction

The phenomenal growth in the production and processing of farm-raised catfish is well known. In 1991, 390 million pounds of catfish were processed by plants reporting to the U.S. Department of Agriculture (USDA, 1992). As the industry develops, increasing amounts of catfish are filleted into further-processed, higher-value products for marketing. The yield (dress-out) of catfish when processed as whole fillets is approximately 45%, generating about 55% offal (Woodruff, 1984). Most of this waste product is currently shipped to a rendering plant, with little or no net return to catfish processors. Consequently, there is interest among processors and researchers in developing higher value use of this waste, particularly the flesh remaining on "frames" from the filleting process. About 18% of the live weight of catfish is frames (Woodruff, 1984).

Surimi can be made from some of the waste produced in the processing plants and, thus, could be an additional source of revenue for processors. Surimi is a Japanese term for a protein material made from fresh fish muscle. The development of surimi technology entered the United States in the last 10 years, but the Japanese have been improving on this technology since the 1100's, especially using lower-valued fish.

Low-cost fish, such as pollock, are deboned and the muscle is minced before going through a series of washings with ice water. Washing removes fat, blood, pigment, and odorous substances. This washed material is then mixed with 4% sucrose, 4% sorbitol, and 0.3% sodium tripolyphosphate to enhance gelation and increase frozen shelf life (Babbitt, 1986).

Surimi is white, odorless, tasteless, and has a texture that is chewy and elastic, which can be made to resemble fish mince from shellfish. It has certain salt-soluble proteins that have the ability to form a stronger gel than most meat proteins. Because of these properties, surimi can be flavored, textured, and formulated for use in a wide variety of foods, not just seafood analogs, but also luncheon meats, meat extenders, sausages, pasta, and snack foods. Surimi is high in protein and low in fat and cholesterol (Food Engineering, 1985).

In 1985, Alaska Pacific Seafoods of Kodiak Island, Alaska, with help from the Alaska Fisheries Development Foundation, was the first U.S. company to produce surimi (Lee, 1986). Currently there are 18 offshore and 7 onshore surimi plants in the United States, plus 13 secondary processors (Marris, 1991). U.S. consumption of surimi analogs has grown from 100 million pounds in 1986, to 150 million pounds in 1991.

Review of Literature

No published information was found on the economics of producing surimi from catfish. Studies have been conducted on the economics of producing surimi from pollock and menhaden (Holmes and Riley, 1987; Hurley, 1989). These studies dealt primarily with establishing a plant for the sole purpose of producing surimi, and thereby did not address the possibility of adding a surimi processing line to an existing processing plant.

Zapata Haynie Corporation evaluated two different methods of producing surimi from menhaden; the batch method, and the continuous method (Hurley, 1989). The batch method is a method in which the mince is washed in batches as opposed to the continuous method where the mince is washed in lines as it passes through the processing operation. They found the continuous process to be superior, based on improved yields and lighter color of the final surimi. They found that a plant capable of producing 22 tons per day would provide for sound financial operation.

No tests have been run using the continuous method for producing surimi from catfish frames. However, some small-scale tests have been conducted on catfish frames using the batch method. The Mississippi Agricultural and Forestry Experiment Station's Coastal Research and Extension Center Seafood Processing Laboratory, located on the Gulf Coast in Pascagoula, evaluated the functional properties of surimi made from catfish frames (Kim et. al, 1992). Results indicated that catfish surimi exhibited functional properties that would be feasible for commercial production of shellfish analogs and other fabricated products.

Objectives

The general objective of this research was to evaluate the economic potential of producing surimi from parts of the waste of processed catfish fillets. Specific objectives aimed at reaching this general objective were:

(1) To estimate the potential supply of catfish frames and trimmings that could be utilized for producing surimi;

(2) To identify equipment requirements for a synthesized processing line and estimate costs of processing catfish frames and trimmings into surimi; and

(3) To assess the overall economic potential of catfish surimi.

Method and Procedure

This study was conducted cooperatively with scientists in the Food Science and Technology Department at Mississippi State Unit and the Coastal Research and Extension Center Seafood Processing Laboratory in Pascagoula, and relied in part on data obtained from their preliminary tests.

For Objective 1, the potential supply of catfish frames and trimmings was estimated from secondary data. From this, an estimated percentage of the total amount of frames and trimmings that could be used to produce surimi was assumed. Much of the information for Objective 2 was obtained from the Coastal Research and Extension Center, which has conducted some preliminary research on producing surimi from catfish. Other data were obtained from companies that design and provide equipment for processing surimi. Yield and cost data were adapted for synthesizing a surimi line in an existing catfish processing plant. For Objective 3, the market potential of catfish surimi was assessed by comparing cost of producing catfish surimi with the wholesale price of surimi produced from other fish.

The Surimi Manufacturing Process

Surimi is a paste-like substance processed into blocks from fish flesh. Basically, fish are deboned and then the flesh is minced, washed, pressed, and formed into blocks. The blocks are then frozen, packaged, and stored in a freezer until shipment.

Deboning/Mincing

The synthesized surimi line starts with a Baader B699 meat bone separator (Figure 1). The mincer is used to separate the muscle from the frames. Catfish frames, by way of an elastic belt, are supplied to a rotating perforated drum (5.0-mm perforations) where continuous pressure is applied. Fish flesh penetrates the perforations into the drum, which discharges into a stainless steel surge tank. The bones and skin are scraped off the drum by knives and are discharged out the bottom of the machine where they will be placed into a container for delivery to a rendering plant.

Washing

The mince that enters the surge tank is mixed with enough water so that it can be pumped into two stainless steel ratio tanks where the first washing takes place. The surge tank is a stainless steel tank with a continuous supply of water being supplied to it. The mince is pumped into the ratio tanks with an RI6 Crepaco pump, where water is added at a ratio of four parts water to one part mince. Ice is also added at the rate of 0.45 pound of ice to one pound of mince. This is the first attempt to remove blood, fat, and other undesirable substances. Most of the fat containing unwanted substances is skimmed off the top of the mixture, and the mince and remaining water are pumped out of the ratio tanks by a Crepaco #6 pump into a rotary screen.

The rotary screen is a long perforated drum that is open on each end and is turned by an electric motor. The drum is mounted horizontally with one end slightly lower than the other. Mince and water are pumped into the higher end of the drum and the mixture slowly moves downward as the drum rotates. The mince continues through the drum and the water exits through perforations. A small amount of water may be used as mist onto the exterior surface of the drum to keep the perforations from becoming clogged. The mince drops out of the lower end of the drum into a stainless steel surge tank where water is added and is then pumped out of the surge tank by another Crepaco #6 pump.

The mince and water mixture is pumped into one of three stainless steel wash tanks where water is added at a ratio of three parts water to one part mince, and ice is again added at the same ratio as before. The mince, water, and ice are then mixed by a stirrer within the tank. The three tanks work separately in order to keep the line moving continuously. While one tank is mixing, the second tank may be filling with water, and the third tank may be emptying the mince out. After the mince and water are mixed, ice is added to the mixture to make the fat solidify and to keep water temperature below 10°C. After a short period of time, the mince settles to the bottom and the fat floats to the top. The fat and water are then removed off the top by a skimmer tube in the tank.

Once most of the water is removed, the mince is pumped out of the tanks by a Crepaco #6 pump. The pump transfers the mince into one of two parallel rotary screens that function in the same manner as the first rotary screen. The rotary screens dump into a large surge tank with two outlets, where the mince is transferred out by two Crepaco #6 pumps.

Refining

The mince is transferred into the feed housing of a Fukoku RE300 refiner. The feed housing feeds the RE300 refiner, which removes particles of skin and bones that passed through the mincer. The mince enters a perforated drum, which has a special auger within it that forces the mince through the perforations and carries the bones and skin out the end. This auger is turned by an electric motor.

Pressing

The mince drops from the perforations into the RE300 discharge hopper where two Crepaco #6 pumps

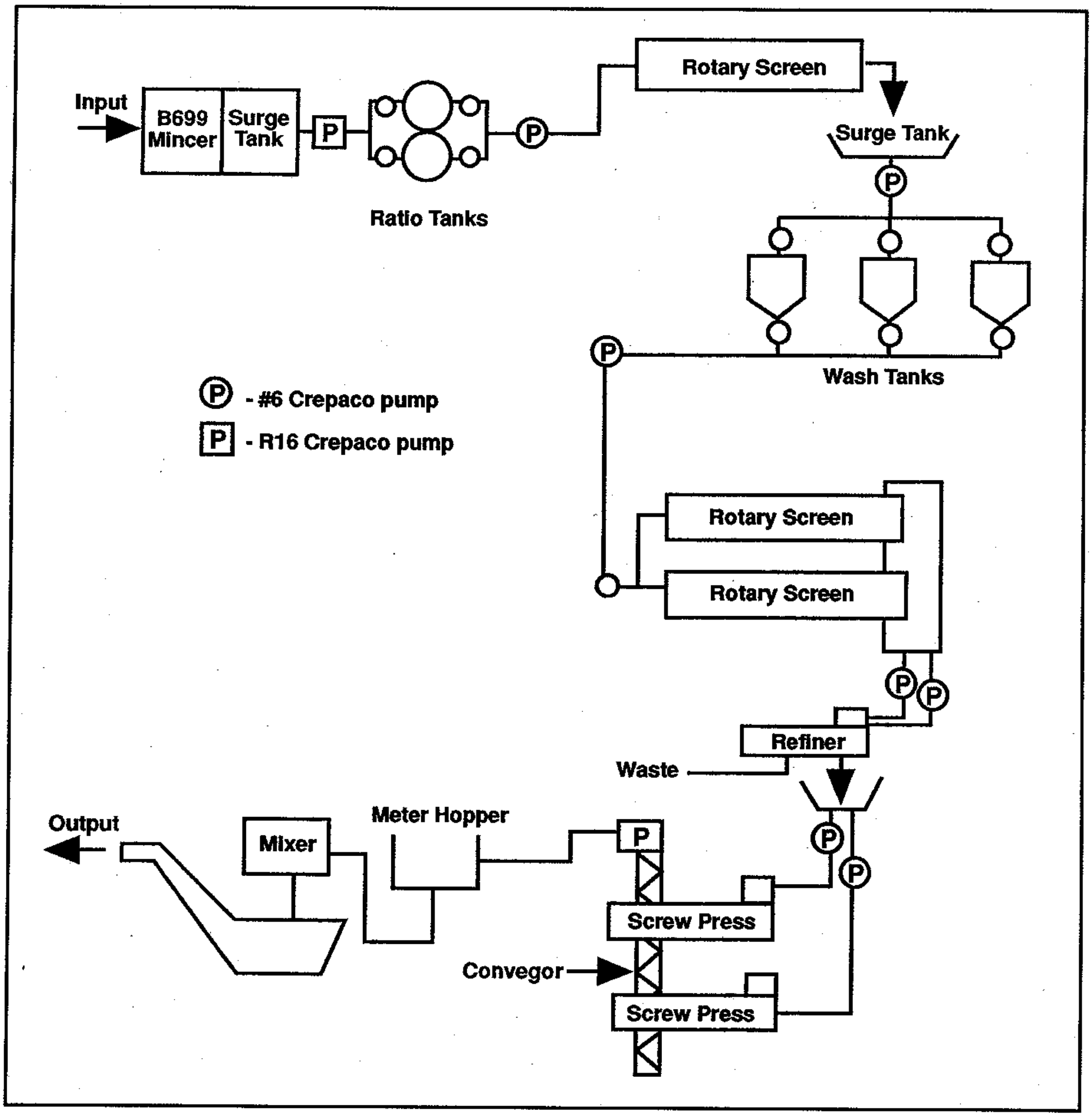

Figure 1. Schematic of surimi processing line.

transfer it into one of two feed housings for two Fukoku HX500 screw presses. The feed housings feed two HX500 screw presses, which are used to remove water. The presses operate much like the RE300 refiner except that water exits through the perforations in the drum and the mince is carried out the end.

The press is a long perforated drum containing an auger that has a small shaft at the beginning that becomes increasingly larger at the end. The drum decreases in diameter toward the exit end. This develops pressure inside the drum and presses the water out through the perforations. This auger is turned by an electrical motor with a gear reducer so that the auger turns at a very slow rate. The two HX500 screw presses discharge onto a discharge conveyor, which carries the mince to a RI6 Crepaco pump.

Mixing

The RI6 Crepaco pump carries the mince into a metering hopper used to measure the correct amount of mince to be pumped into a Fukoku mixer. The metering hopper has a built-in pump. The mince is then mixed with 4% sucrose, 4% sorbitol, and 0.3% sodium tripolyphosphate to increase frozen shelf life by preserving protein characteristics and minimizing freezer burn.

Extruding

The finished mix (surimi) leaves the mixer and is transferred into a meter hopper with pump and extruder. This extruder uses pressure to shape the surimi into a rectangular form. It is then cut into 25-pound blocks, which are placed onto surimi pans.

Freezing and Packaging

The pans of surimi are placed onto a conveyor that feeds the plate freezer. This plate freezer freezes the surimi blocks to -29°C in minimal time. The frozen surimi is removed from the pans and sent through a metal detector to insure safety. The surimi is then boxed in wax-covered boxes in quantities of two 25-pound blocks per box. The boxes are glued shut and placed in a storage freezer until sold.

Cost of Processing

Supply of Catfish Frames

To determine the appropriate capacity of the synthesized surimi line, the total quantity of frames and trimmings produced in Mississippi processing plants was estimated. All processing plants in the United States reporting to USDA processed 390,870,000 pounds of catfish in 1991 (USDA, 1992). Since there is no information published on processing by states, it was assumed that since Mississippi contains approximately 70% of all acreage devoted to catfish in the United States, the state processes 70% of the nation's catfish. By this assumption, Mississippi processed 273,609,000 pounds of catfish in 1991. Of this, an estimated 188,790,210 pounds went into filleting operations.

Woodruff estimated that frames and trimmings make up 18 percent of the total weight of catfish being filleted (Woodruff, 1984). This implies that 33,982,237 pounds of frames and trimmings were available in Mississippi in 1991. It was assumed that one surimi processor in Mississippi could recover an ample quantity of frames and trimmings (approximately 21.6 million pounds) to supply a surimi processing line.

It was assumed that the surimi line would operate 250 days per year, based on a 5-day work week for 50 weeks. It was also assumed that the line would run 24-hour days. For purposes of calculating capacity, it was assumed that out of a 24-hour day, the line would run 20 hours, the remaining 4 hours would be time for cleanup, repairs, maintenance, and shift changes.

Based on the estimate of 27,616,500 pounds of frames and trimmings and 20 hours per day for 250 days per year, the surimi line should be capable of handling approximately 110,000 pounds per day. This represented the typical surimi plant set up for producing surimi from pollock. Modifications reducing the number of washings were made by the food processing scientists and engineers at the Coastal Research and Extension Center to better accommodate the processing of catfish frames and trimmings (Kim, et. al, 1993).

Building

It was assumed that the surimi processing line would be added to an existing catfish processing plant. It was estimated that this processing line would require 10 percent of the land and building based on a plant capable of processing 160,000 pounds of processed catfish per day (Fuller, 1984). Ten percent of investment in land would cost $5,380, and land and buildings total $234,003, giving the surimi processing line 5,000 square feet of floor space. It was estimated that only 3,000 square feet would be needed for the actual processing line, leaving 2,000 square feet for office space and a share of the restrooms, break room, and freezer floor space.

Parking and Loading

It was assumed that since most catfish processing plants are operating at a level below full capacity, no additional parking area would be required. The day shift for the surimi line would employ the most (11) people.

The catfish plant would also have the loading docks needed for unloading frames from other plants and loading out of processed surimi. The addition of the trucks loading surimi should not be a problem since only about eight truckloads per month would be required to haul the surimi based on a load weight of 40,000 pounds per truck. Some modifications in an existing plant might be required to accommodate moving frames from loading dock to processing line.

Equipment

The equipment used in this processing line was suggested by Flohr Metal Fabricators (Johnson, 1992). Minor modifications were made by food scientists and engineers at the Coastal Research and Extension Center.

Investment Cost

Estimated investment requirements for the processing line are summarized in Table 1. Investment requirements for each piece of processing equipment, and office equipment, are contained in Appendix Tables 1 and 2. The initial investment requirements are based on the equipment needed for the processing line and the office, and a share of the building, land, and waste treatment facility available at an existing catfish processing plant.

These investment requirements deal exclusively with the processing of available catfish frames into surimi. Additional investment costs would be incurred for the trucks needed to haul frames from other catfish processing plants to the surimi processing line.

Estimated investment requirements expressed as a percentage of the total can be found in Table 1. The processing equipment represents the largest portion of the total with a 79.73% share. Since only a 10% share of the building is required for processing surimi, the investment of the building makes up only 15.13% of the total. The land, waste treatment facility, office equipment, and storage freezer represent a very small share of the total.

Of the 79.73% share of the processing equipment, the washing equipment accounts for 14.43% of the total investment with the pressing equipment accounting for 13.76% of the total. The plate freezers make up the smallest portion of the processing equipment with a 1.98% share of the total.

Annual Ownership Costs

Annual ownership costs are those fixed costs that occur on an asset after its purchase whether it is in use or not. Ownership costs include interest, insurance, taxes, and depreciation. These costs are shown in Table 2.

Table 1. Estimated investment requirements and percent distribution by item for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item	($)	%
Land	5,380	0.35
Building	228,623	15.13
Waste Treatment Facility	40,000	2.64
Processing Equipment:		
Mincing	110,000	7.28
Washing	218,000	14.43
Refining	77,000	5.09
Pressing	208,000	13.76
Mixing	160,000	10.59
Extruding	112,000	7.41
Freezing	30,000	1.98
Packaging	100,000	6.62
Electrical/Piping	190,000	12.57
Sub-total Proc. Eq.	1,205,000	79.73
Office Equipment	13,270	0.88
Storage Freezer	19,150	1.27
TOTAL	$1,511,423	100.00

Table 2. Annual ownership cost and percent distribution by item for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item	$	%
Building depreciation	9,145	3.78
Processing equipment depreciation:		
Mincing	13,575	5.60
Washing	19,516	8.06
Refining	9,450	3.90
Pressing	21,100	8.71
Mixing	16,000	6.60
Extruding	10,467	4.32
Freezing	3,000	1.24
Packaging	10,000	4.13
Electrical/Piping	19,000	7.84
Sub-total	122,108	50.40
Office equipment depreciation	1,319	0.54
Storage freezer depreciation	1,915	0.79
Insurance	8,778	3.62
Taxes	21,162	8.74
Interest on investment capital	77,841	32.12
TOTAL	$242,268	100.00

Depreciation

Depreciation was calculated using the straight line method of depreciation assuming a zero salvage value. The expected life of the building was estimated to be 25 years and the expected life of the processing equipment and office equipment is shown in Appendix Tables 1 and 2. Depreciation on the equipment makes up more than 50% of the total annual ownership costs (Table 2).

Insurance

The insurance coverage for the processing line includes fire, vandalism, hail, smoke, water, and most other types of disaster. Theft insurance was not included due to the size of the processing equipment, which would require heavy equipment to move it. Insurance is considered to be an ownership cost because whether the equipment is being used or not, it is still subject to being destroyed by unforeseen disasters. The insurance covers the building, all equipment, storage freezer, and the surimi in the storage freezer. The insurance cost was estimated using a rate of $.55 per $100 of building, equipment, and 2 week's inventory, totaling $8,778.

Taxes

Property taxes are figured on the assessed value of the land, building, equipment, and inventory as of January 1 of each year. Property taxes are considered part of the annual ownership cost because they are payable whether the line is in operation or not. The appraised value of the building and the equipment was assumed to be original cost, while the value of the land was based on those values levied by the Mississippi Tax Commission. The value of the inventory was based on 2 weeks of production. A tax rate of 86.53 mills was levied on 15% of the appraised value of the land, building, equipment, and 2 week's worth of inventory. The tax rate was derived by taking an average of the tax rate of the larger catfish producing counties in the Mississippi Delta.

Interest on Investment Capital

An interest rate of 10% was charged on one-half of the investment on depreciable assets, such as the processing equipment, office equipment, building, and the storage freezer. Interest is charged on one-half of the investment because one-half of the initial investment is the average investment over the item's estimated life. An interest rate of 10% was also charged on the full value of the nondepreciable items, which include the land and the waste treatment facility. Interest on average investment totaled $77,841 per year for the processing line.

Operating Requirements and Costs

Annual operating costs are those costs incurred because of the operation of the business. These costs consist of utilities, repairs and maintenance, labor, supplies for the processing line and the office, and interest on operating capital. Annual operating costs are shown in Table 3. The largest component of operating cost is labor, which represents 45% of the total.

Labor Requirements

Since it was assumed that the surimi processing line would operate separately within an existing catfish plant, it was felt that a general manager should be hired to manage the entire operation of the surimi line, along with a secretary. A supervisor/food technologist and eight workers would be required for each shift (Table 4).

Manager. The manager would have the responsibility of managing the entire surimi processing line from procurement to sales. Responsibility would include the procurement of frames and the marketing of the finished product. The manager would be responsible for hiring employees and maintaining good worker relations. A salary of $50,000 per year, plus fringe benefits of $10,000 per year, were assumed necessary

Table 3. Annual operating cost and percent distribution by item for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item	$	%
Utilities		
Electricity	65,100	5.72
Water	9,168	0.80
Telephone	18,480	1.62
Sub-total, utilities	92,748	8.14
Labor		
Salaried	189,600	16.65
Hourly	324,300	28.47
Sub-total, labor	513,900	45.12
Repairs & Maintenance	128,029	11.24
Processing Supplies		
Ice	57,000	5.00
Sucrose	57,995	5.09
Sorbitol	136,703	12.00
Sodium triphosphate	4,142	0.36
Packaging	57,995	5.09
Sub-total, processing supplies	313,835	27.54
Office Supplies	31,154	2.74
Miscellaneous Supplies	15,577	1.37
Travel	25,000	2.20
Total Operating Capital	1,120,243	
Interest on operating capital	18,671	1.64
TOTAL	$1,138,914	100.00

Table 4. Estimated personnel requirements by type for each shift for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

	Shift			
Type	1	2	3	Total
Manager	1			1
Secretary	1			1
Supervisor/Food Technologist	1	1	1	3
Operator for				
Mincing	1	1	1	3
Washing	2	2	2	6
Refining/Pressing	1	1	1	3
Mixing	1	1	1	3
Extruding/Freezing	1	1	1	3
Packaging	1	1	1	3
Utility Worker	1	1	1	3
TOTAL				29

to employ a manager capable of carrying out these responsibilities.

Secretary. The secretary would be responsible for keeping records of production and sales based on reports by the supervisors, along with the day-to-day secretarial duties of taking messages and typing letters and memos. The secretary would receive a salary of $18,000 per year, plus fringe benefits of $3,600 per year.

Supervisor/Food Technologists. Three supervisor/food technologists would be required, one for each shift. Their responsibilities as supervisors would be to assure that each worker understands and performs his or her job. They would be responsible for keeping records of production to be turned over to the secretary for permanent records. As food technologists, they would be responsible for monitoring the processing of the surimi from a technical standpoint. They would be responsible for making sure the surimi being processed is of the highest grade possible and that no problems exist. It was assumed that each supervisor/food technologist would receive a salary of $30,000 per year, plus fringe benefits of $6,000 per year.

Mincing. One person per shift would be required to operate the mincer, which consists primarily of feeding frames into the mincer. This worker must make adjustments to the mincer several times a day as needed. The operator of the mincer must also change the belt about every 130,000 pounds, which results in an average of 4.25 belts per week. Occasionally, the mincer must be stopped to unclog the discharge area or to scrap off particles that have clogged the perforations within the drum. The mincer operator would receive a wage equivalent of $12,000 per year (based on $6 per hour, 40 hours per week) and fringe benefits of $1,800 per year.

Washing. Two people per shift would be required to handle the washing of the mince. They are responsible for the first washing, which takes place in one of two ratio tanks where the correct ratio of water and ice to mince is added, the water is removed, and the mince pumped into one of three wash tanks. The second washing requires the most labor because the workers have to add water and ice to the mince and turn on a device that works much like a mixer and constantly stirs the mixture. Once this mixture has settled, the worker would be required to skim off the fat and water on the top, and pump it into one of two rotary screens. The two workers would be responsible for keeping the pumps in working order and for keeping the wash tanks clean. They also would be required to maintain the rotary screens to make sure they are functioning properly. They would receive $12,000 per year (based on $6 per hour, 40 hours per week) and fringe benefits of $1,800 per year.

Refining/Pressing. One worker per shift would be required to operate the refiner and the two screw presses. This worker would be responsible for keeping the refiner, screw presses, and pumps from plugging up, and for keeping the pumps in working order. The operator of the refiner and screw presses would receive $12,000 per year (based on $6 per hour, 40 hours per week) and fringe benefits of $1,800 per year.

Mixing. One worker per shift would be required to operate the mixer. This worker would be responsible for adding the correct amount of additives to the mince and mixing the ingredients for a given time period before dumping the mixture into a metering hopper, which feeds the extruder. The mixer operator would be responsible for keeping the supervisor advised as to when more additives need to be ordered. The operator of the mixer would receive $12,000 per year (based on $6 per hour, 40 hours per week) and fringe benefits of $1,800 per year.

Extruding/Freezing. One worker per shift would be required to operate the extruder. This worker would be responsible for keeping surimi pans and bags placed in the extruder and for keeping the pump that pumps the surimi from the metering hopper to the extruder from clogging up. This worker would also be responsible for keeping the conveyor running, and for keeping check on the plate freezers to make sure they are operating correctly. The operator of the extruder would receive a wage equivalent of $12,000 per year (based on $6 per hour, 40 hours per week) and fringe benefits of $1,800 per year.

Packaging. One worker per shift would be required to remove frozen surimi pans from the plate freezer, remove the bag of surimi from the pan, place two bags into a box, then glue the box shut. This person would return the surimi pans to the extruder. This worker would also stack the boxes of surimi on pallets and store them in the walk-in freezers. The wage equivalent for this worker would be $12,000 per year (based on $6 per hour for 40 hours per week) and fringe benefits of $1,800 per year.

Utility Worker. One utility worker per shift would be required to fill in for other workers during breaks, vacation, and sick leave. The utility worker would also assist other workers who are having trouble because of mechanical breakdown or some other problem. When not helping other workers, the utility worker would keep the area around the processing line clean and orderly. The utility worker would receive $10,000 per year (based on $5 per hour, 40 hours per week) and fringe benefits of $1,500 per year.

Labor Cost

The wages for the salaried personnel result in a cost of $189,600 and the wages for the hourly personnel result in a cost of $324,300. The total wages for the processing line result in a cost of $513,900 (Table 5). A rate of 20% was assumed for fringe benefits for the salaried personnel and a rate of 15% was assumed for the hourly personnel. A wage rate of $6 per hour was paid to all hourly personnel except for the utility worker, who was paid $5 per hour.

Utility Requirements and Cost

Electricity. Electrical requirements for the processing line were based on data provided by Flohr Metal Fabricators (Johnson, 1992). These requirements are summarized in Appendix Table 3 based on data in Appendix Table 4. The plate freezers and the storage freezer make up the largest portion of the electrical requirements of the processing line. Electrical requirements were calculated assuming processing equipment operating 20 hours per day, 22 days per month; the freezer operating 24 hours per day, every day of the month; the lighting and office equipment operating 24 hours per day, 22 days per month; and miscellaneous operating 24 hours per day, 22 days per month.

Electrical costs are based on a demand charge and a secondary charge. A demand charge is based on the maximum amount of kilowatts required by the plant at any given hour. The processing line fell into the first demand charge of any demand under 200 kW. This is a cost of $820 whether any electricity is used or not. The secondary charge was based on the actual kWh usage. Based on Mississippi Power and Light charges, the first 40,000 kWh cost $0.056/kWh and all over that cost $0.055/kWh. This line had an overall usage of 83,066 kWh/month which results in an overall secondary charge of $4,605 per month and a total electrical cost of $5,425 per month, or $65,100 annually.

Water and Ice. It was estimated that 12 parts of water would be required to one part of mince. Based on the estimate of 50 percent yield of mince from 5,097 pounds of frames processed per hour, 2,549 pounds of mince per hour, or 12,745,000 pounds per year would be obtained. This results in a water requirement of 152,940,000 pounds or 18,327,142 gallons of water per year. Based on a charge of $0.50 per 1,000 gallons, this results in a monthly water cost of $764, or an annual cost of $9,168. The estimate of 12:1 water to mince was based on the assumption of two washings, which

Table 5. Estimated salary and fringe benefit costs for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Type	Number	Salary or Wage	Fringe Benefits	Cost Each type	Total
		$	$	$	$
Manager	1	50,000	10,000	60,000	60,000
Secretary	1	18,000	3,600	21,600	21,600
Supervisor/Food Technician	3	30,000	6,000	36,000	108,000
Operator for					
Mincing	3	12,000	1,800	13,800	41,400
Washing	6	12,000	1,800	13,800	82,800
Refining/ Pressing	3	12,000	1,800	13,800	41,400
Mixing	3	12,000	1,800	13,800	41,400
Extruding/ Freezing	3	12,000	1,800	13,800	41,400
Packaging	3	12,000	1,800	13,800	41,400
Utility Worker	3	10,000	1,500	11,500	34,500
Total	29				513,900

require 4:1 ratios of water to mince, the use of three surge tanks, one rotary screen and one double rotary screen, and water used in the cleanup process.

Total quantity of ice required amounts to 5,700,000 pounds annually based on the ratio of 250 pounds of ice to each 550 pounds of mince. Assuming the cost of ice is $1 per hundredweight, annual cost of ice totals $57,000.

No cost, other than a 25% share of the investment in the waste treatment facility, was charged for the disposal of the waste water. Experts at Clearwater Consultants in Starkville, MS, agree that the larger catfish processing plants in the Mississippi Delta can easily accommodate 1.5 million gallons per month extra in the treatment facility. However, if this facility did not exist, construction of a facility to handle this amount of waste water would cost approximately $160,000.

Telephone. It was estimated that 20 calls per day would be made by the processing line personnel to procure frames from other plants and to sell of the surimi. Assuming 22 working days per month and an average cost of $3.50 per call, this would result in a telephone cost of $1,540 monthly, or $18,480 annually.

Repairs and Maintenance

Repairs and maintenance for the surimi processing line were calculated as a percentage of new cost of the equipment (McAlpin, 1993). Annual repairs, summarized in Table 6, were estimated to be $128,029, due largely to the cost of replacing the belts used on the Baader B699 mincer. The belt on the mincer must be replaced after about every 130,000 pounds of raw material at a cost of $500 per belt. This results in an average of approximately 4.25 belts per week. As shown in Table 6, the repairs and maintenance on the processing equipment accounts for 97.35% of the total annual repairs and maintenance of the processing line. The repairs and maintenance on the mincer alone account for 83.22% of the total.

Table 6. Annual repair costs and percent distribution by item for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item	$	%
Building	2,286	1.79
Processing Equipment:		
Mincing	106,555	83.22
Washing	3,460	2.70
Refining	1,650	1.29
Pressing	3,600	2.81
Mixing	1,600	1.25
Extruding	900	0.70
Freezing	900	0.70
Packaging	2,500	1.95
Electrical/Piping	3,500	2.73
Sub-total	124,665	97.35
Office Equipment	120	0.09
Storage freezer	958	0.75
TOTAL	128,029	100.00

Supplies and Miscellaneous Costs

There are five major supplies needed for the processing of surimi; ice, sorbitol, sugar, sodium tripolyphosphate, and packaging material. Cost of these supplies per pound of surimi are: ice, $0.014; sorbitol, $0.033; sugar, $0.014; sodium tripolyphosphate, $0.001; and packaging material, $0.014. This results in an annual cost of $57,000 for 5,700,000 pounds of ice, $136,703 for 153,000 pounds of sorbitol, $57,995 for 153,000 pounds of sugar, $4,142 for 11,475 pounds of sodium triphosphate, and $57,995 for packaging material. These costs are based on a 30 percent yield of surimi from 2,550 pounds of mince per hour for a total yearly production of 4,142,475 pounds of surimi.

Office supply costs were calculated using 3% of annual operating costs. These costs represent all office overhead such as paper, pens, notepads, etc., as well as postage. A travel allowance of $25,000 was included in the operating costs for the manager to travel on sales trips and for the food technicians/supervisors to travel to conferences to learn about new techniques in surimi processing. Miscellaneous supply costs were calculated using 1.5% of annual operating cost. Miscellaneous costs include such items as cleaning and sanitation materials, water hoses, gloves, and aprons.

Interest on Operating Capital

Interest on operating capital was calculated using an interest rate of 10% on one-sixth of total operating capital. Interest was calculated to be $18,671 on $1,120,243 of annual operating capital.

Annual Cost Analysis

The annual cost associated with operating a surimi processing line was estimated to be $1,381,182, as shown in Table 7. Based on the assumptions of 50% mince yield from frames and 30% of the mince making surimi, the line will process 4,142,475 pounds of surimi per year. This would result in a cost of $0.3334 per pound for the processing of surimi from catfish frames and trimmings, assuming zero cost for frames and trimmings.

Table 7 shows that 82.46% of the total cost of producing surimi is operating costs, or $0.2749 per pound. Ownership costs amount to 17.54%, or $0.0585 per pound. Labor makes up the largest percentage of total costs with 37.21%, followed by processing supplies with 22.72%.

Table 7. Total annual cost, cost per pound, and percent distribution of total by item, for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item	Total cost	Cost per lb	Percent
	($)	(¢)	(%)
Ownership			
Depreciation	134,487	3.25	9.74
Insurance	8,778	0.21	0.64
Taxes	21,162	0.51	1.53
Interest	77,841	1.88	5.64
Total, Ownership	242,268	5.85	17.54
Operating			
Utilities	92,748	2.24	6.71
Labor	513,900	12.41	37.21
Repairs and Maintenance	128,029	3.09	9.27
Processing Supplies	313,835	7.58	22.72
Office Supplies	31,154	0.75	2.26
Misc. Supplies	15,577	0.38	1.13
Travel	25,000	0.60	1.81
Interest on Oper. Capital	18,671	0.45	1.35
Total, Operating	1,138,914	27.49	82.46
Total, All Cost	$1,381,182	33.34	100.0

Effect of Increased Yield

Estimates of costs were based on a yield of 15% surimi from catfish frames and trimmings. Specialists at the Pascagoula Laboratory suggest yields as high as 20% may be possible. The yield increase could be due to more trimmings, or new technology designed especially for producing surimi from catfish, and operating the line continuously to reduce waste. If this yield was increased to 20%, the only costs that would be changed are those based on the pounds of surimi processed—sorbitol, sucrose, sodium tripolyphosphate, packaging material, and possibly more ice. All other costs would remain the same because the processing line would still be processing the same amount of input but would be receiving a larger yield.

If a yield of 20% could be achieved, total pounds processed would increase from 4,142,475 pounds to 5,523,300 pounds annually Operating costs would increase by $104,941 because of the purchase of more processing supplies. Total annual costs would increase from $1,381,181 to $1,486,122. Production costs per pound of surimi would consequently decrease from $0.3334 to $0.2691, or a difference of $0.0643 per pound.

Cost of Frames

The costs of assembling, handling, and transporting frames and trimmings were not addressed in this study. Because of the low yield, any cost of frames and trimmings will add significantly to the cost of surimi. Table 8 shows the cost of processing surimi under varying assumptions regarding the cost of the frames and variations in yield.

Costs were calculated for two yield levels (15 and 20%) and three levels of cost for frames and trimmings ($0.05, $0.10, and $0.15 per pound). Assuming a 15% yield, 6.67 pounds of frames and trimmings are required to produce one pound of surimi, whereas 5 pounds of frames and trimmings are required based on a 20% yield.

Approximately 50% of the total weight of the frames and trimmings after being deboned could possibly be sold to a rendering plant, which would recover some of the revenue used to purchase the frames and trimmings[1]. However, this potential revenue was not subtracted from estimated cost.

The costs for assembling and hauling the frames and trimmings to the processing line were not included because this line could be added to one of the larger existing catfish processing plants, which would provide a large share of the frames and trimmings needed for processing. If the line was added to a small catfish processing plant most of the frames and trimmings needed for the processing would be procured from other processors, resulting in additional costs for assembly and transportation.

Table 8. Cost per pound of producing surimi based on varying levels of yield and price of frames in the Mississippi Delta, 1992.

Cost of frame and trimmings	Yield 15%	Yield 20%
($/lb.)		
0.00	0.3334	0.2691
0.05	0.6667	0.5191
0.10	1.0000	0.7691
0.15	1.3334	1.0191

Assessment of Market Potential

Consumption of surimi-based products in the United States grew to 150 million pounds in 1990, and all indications are that demand will continue to expand. The wholesale price of surimi has varied from as low as $0.85 per pound in 1990 to as high as $2.25 per pound in late 1991. Based on a 15% yield and a price of $0.05 per pound for frames and trimmings,

[1]Removal of frames and trimmings would undoubtedly affect the quality and price of offal sold for rendering. Even if the bone and fat recovered from surimi processing was added back to the offal from catfish processing, additional costs would likely be generated.

estimated total cost of producing surimi was $0.6667 per pound. Even at the low price of $0.85 per pound for surimi, catfish surimi would be profitable, assuming frame procurement costs, marketing costs, and other costs did not exceed $0.18 per pound of processed surimi.

Assuming that a 20% yield could be achieved, and that frames could be assembled for $0.10 per pound, surimi processing still appears to be feasible at wholesale surimi prices above $0.85 per pound.

Summary, Conclusions, and Limitations

Summary and Conclusions

The farm-raised catfish industry processed 390 million pounds of catfish in 1991. Well over half of these fish were processed into fillets, which produced a large quantity of frames and trimmings. Approximately 18% of the live weight of catfish being filleted is frames and trimmings. Of this 18%, approximately 50% is recoverable mince. If a surimi processing line could recover 27,616,500 pounds of the frames and trimmings produced in Mississippi, this would yield 13,808,250 pounds annually of mince, which could in turn would yield at least 4,142,475 pounds of surimi.

Surimi is a paste-like substance processed from fish flesh. Basically, the flesh is deboned, minced, washed, pressed, and formed into blocks. The blocks are then frozen, packaged, and stored in a freezer until shipment.

The objectives of this study were to identify investment and operating requirements and costs of processing surimi in an existing catfish processing plant. With assistance from Flohr Metal Fabricators in Seattle, WA, and the Coastal Research and Extension Center's processing laboratory in Pascagoula, a processing line was synthesized with the capacity to process approximately 110,000 pounds of frames and trimmings per day. Assuming a 15% yield, this amounts to 16,500 pounds of processed surimi per day.

Investment requirement for adding to an existing plant a surimi processing line capable of producing 4,142,475 pounds of surimi per year was estimated to be $1,511,423, which includes a share of existing plant. New processing equipment required amounted to $1,218,270, or approximately 80% of the total investment. The remaining 20% represented an appropriate share of investment in an existing plant, including freezer space.

A total of 29 laborers, 24 of whom could be unskilled, would be needed to maintain the surimi processing line. Estimated total salary and wages amounted to $513,900 annually.

This study reveals that the total annual cost to operate a surimi processing line capable of producing 4,142,475 pounds of surimi annually would be $1,381,182, of which approximately 82% is operating costs. This results in a total processing cost of $0.3334 per pound of surimi, assuming a 15% yield and a zero cost for frames. If a yield of 20% could be achieved, the total processing cost would drop to $0.2691 per pound.

As the cost of frames increases, total cost of processed surimi increases. Total cost was estimated to be $0.6667 per pound assuming $0.05 per pound for frames and trimmings based on a 15% yield. Assuming a yield of 20% and a more reasonable expectation of $.10 per pound for frames, estimated cost per pound of surimi totaled $.7691. Given the wholesale price range of $.85 to $2.25 observed in the recent past, surimi processing appears to be economically feasible.

The demand for surimi is continually growing and putting pressure on the supply of pollock, which has been the major source of minced fish used for surimi. As demand for surimi grows, suppliers will continue to look for alternatives to pollock. Byproducts from catfish processing may be an alternative as the catfish industry continues to grow.

Limitations and Implications

Cost estimates included only those costs incurred once the frames and trimmings were received and up until the surimi left the loading dock. Hauling and distribution costs and most other marketing charges were not included in this study. The only marketing charge included in estimated cost was a salary for the manager, telephone calls, and a travel expense account.

The capacity of the synthesized processing line is basically the smallest available for commercial application. The capacity of the line could be increased significantly with the addition of another Baader B699 deboner because the rest of the line is operating below full capacity. This would reduce per unit cost. There may be other size economies associated with procurement of frames, processing, and marketing that should be assessed in future research.

New technology in the form of a deboner designed especially for catfish frames could play a large role in decreasing the cost of producing surimi. More than $106,000 annually is required to replace belts for the deboner.

The processing line was designed to operate three shifts a day rather than one shift a day because of the amount of product that would be lost at the end of each day to shut down. The screw presses and the extruder operate by incoming product forcing out the outgoing product. At the end of the day, there would be about 200 pounds of product lost within these three pieces of equipment. More water would be used in this process becasue of the lengthy cleanup period. If the line ran only one shift, another shift of two laborers would be required for cleanup. Consequently, the cost per pound for processing surimi would increase if the line was run only one shift a day as most catfish processing plants currently do.

Another type of line called the in-line or continuous wash system is also being used in surimi processing. The synthesized line in this study included the batch wash method because no studies using the in-line wash on mince from catfish frames and trimmings had been done. The in-line wash system requires less labor and water than the batch method and should be evaluated in future research.

Some byproducts would be produced from the surimi line. Of the frames and trimmings, 50% becomes mince and the other 50% is waste, which possibly could be sold to a rendering plant. Also, fat is removed in the washings and could easily be separated from the waste water. Surimi processing plants recover the fat and sell it, however no tests have been run to determine the yield of fat from catfish frames and trimmings. Further, the impact on quality of offal from catfish processing resulting from removal of catfish frames and trimmings needs to be quantified.

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Appendix Tables

Appendix Table 1. Estimated processing equipment cost by item for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item (and number)	New cost	Estimated life	Depreciation	Maintenance & repairs
	($)	(Yr)	($)	($)
Meat-bone separator (1)	95,000	8	11,875	106,195
Surge tanks (3)	11,000	15	733	0
R16 Crepaco Pumps (2)	24,000	8	3,000	720
Ratio tanks (2)	26,000	15	1,733	0
Crepaco #6 Pumps (7)	70,000	8	8,750	2,100
Rotary screen (1)	20,000	10	2,000	400
Wash tanks (3)	72,000	15	4,800	720
Double rotary screen (1)	42,000	10	4,200	840
Feed housings (3)	6,000	10	600	300
RE300 Refiner (1)	50,000	8	6,250	1,000
Discharge hopper (1)	5,000	10	500	50
HX500 Screw presses (2)	180,000	10	18,0 00	2,700
Discharge screw conveyor (1)	12,000	10	1,200	240
Metering hopper/ pump (1)	40,000	10	4,000	1,000
Mixer (1)	120,000	10	12,000	600
Metering hopper/ pump/extruder (1)	90,000	10	9,000	900
Surimi pans (400)	22,000	15	1,467	0
Plate freezers (3)	30,000	10	3,000	900
Conveyor/packaging (1)	100,000	10	10,000	2,500
Freezer[a]	19,150	10	1,915	958
Lot electrical (1)	160,000	10	16,000	3,200
Lot piping (1)	30,000	10	3,000	300
Total	1,224,150		124,023	125,623

[a]Twenty-five percent share of existing freezer

Appendix Table 2. Estimated office equipment cost by item for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

Item (and number)	New cost	Estimated life	Depreciation	Maintenance & repairs
	($)	(Yr)	($)	($)
Chairs (10)	1,760	5	352	0
Desks (3)	1,400	15	93	0
Credenzas (2)	960	15	64	0
File cabinets (6)	2,850	15	190	0
Computers (3)	6,000	10	600	120
Work Center	300	15	20	0
Total	13,760		1,319	120

Appendix Table 3. Data used to estimate monthly electrical requirements for a surimi processing line in an existing catfish processing plant, Mississippi Delta, 1992.

	kWh/hr	hr/day	day/mo	total kWh/mo
Equipment	148.75	20	22	65,450
Freezer	22	24	30.5	16,104
Lighting and office equipment	0.75	24	22	396
Miscellaneous	2	24	22	1,056
Total kWh/month				83,006

Appendix Table 4. Data used to estimate electrical requirements for a surimi processing line in an existing catfish processing plant in the Mississippi Delta, 1992.

Item (and number)	Electrical usage, each item (kW/h)
Meat-bone separator (1)	5.50
R16 Crepaco Pumps (2)	3.75
Ratio tank	0.75
Ratio tank	0.75
#6 Crepaco Pumps (7)	2.25
Rotary screen	1.50
Wash tank	1.25
Wash tank	1.25
Wash tank	1.25
Double rotary screen	3.00
Refiner	15.00
Screw presses (2)	2.25
Discharge screw conveyor	2.25
Metering hopper/pump	6.00
Mixer	15.00
Meter hopper/pump/extruder	7.50
Plate freezers (3)	15.00
Conveyor/Packaging	15.00
Freezer	22.00
Manager's office	0.25
Secretary's office	0.25
Supervisor/Food technician	0.25
Misc.	2.00

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