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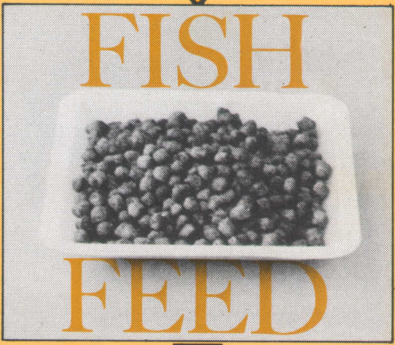
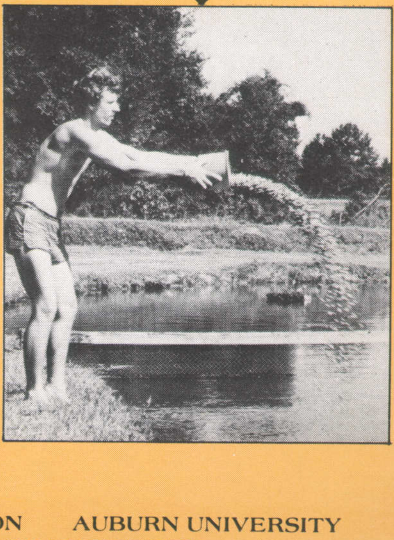


Utilization of Catfish Processing Waste



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UTILIZATION OF CATFISH PROCESSING WASTE

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INTRODUCTION

Catfish processing waste, consisting of heads, skin, and viscera, accounts for at least 40 percent of the volume of product that enters catfish processing plants. This represents a potential source of nutrients of considerable value for livestock, pet, and fish feeds.

In 1979 there were 40 million pounds of farm-raised catfish processed by six plants located in Alabama and Mississippi (National Marine Fisheries Service, 1979). Processing waste from this quantity of catfish represents 2.2 million pounds of relatively high quality animal protein, 24 million megacalories of digestible energy, 0.11 million pounds of available phosphorus, and 0.22 million pounds of calcium.

If these nutrients were simply recycled back through catfish, there would be enough protein (if no other protein were fed) to produce 4.5 million pounds of fish, enough digestible energy to produce 18.9 million pounds of fish, or enough available phosphorus to produce 19.2 million pounds of fish. If catfish processing waste supplied only one-fourth of the dietary protein (in a diet containing approximately 16 percent dried catfish waste) there would be enough protein to produce 18 million pounds of catfish or 45 percent of the fish processed in 1979.

To date, the catfish industry has not made profitable use of catfish waste, mainly because of erratic supply and lack of technical information concerning value of waste and methods of utilization. Wastes from poultry and livestock processing plants are

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recycled into feeds for food animals. This also appears to be an economical use for catfish processing waste.

A series of studies was conducted at the Auburn University Agricultural Experiment Station to determine chemical, nutritional, and relative economic values of waste from processing plants and evaluate its use in fish, swine, and pet diets.

EXPERIMENTAL PROCEDURES

Chemical Composition of Catfish Processing Waste

Sixty samples of catfish processing waste (head, skin, and viscera) were collected from four commercial plants during October and March, over a 2-year period, for measurement of nutrient and chemical composition. These values vary with size and condition of fish (fish harvested in the fall contain more fat than those harvested in the spring). Each sample contained by weight 57 percent heads, 28 percent viscera, and 15 percent skins, which is the average ratio of these parts in the total processing waste. For each sample, the parts were frozen, ground twice (first through a ¼-inch, then a ⅛-inch plate) with a food grinder, and homogenized. Each sample was analyzed for moisture, fat (Gerber method), crude protein, ash, calcium, and phosphorus by AOAC methods (1). Four of the samples were analyzed for amino acids and fatty acids by a commercial laboratory[1].

Biological Value of Protein in Catfish Waste

A feeding experiment with channel catfish fingerlings was conducted to compare the protein quality of catfish waste with that of other protein sources, especially marine fish meal. Twenty-five fish (average weight of 0.02 pounds each) were placed in 15-gallon flowing-water aquariums (0.25 gal./minute), 84° Fahrenheit, and five test diets were fed to triplicate aquariums of fish. The diets were nutritionally adequate and isocaloric, the only difference being source of protein. The diets were prepared as moist (27 percent water), 4-millimeter diameter pellets, and frozen until fed. The fish were fed to satiation two times daily for 10 weeks and weight gain and dietary protein intake were measured.

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[1]Analytical Bio Chemistry Laboratories, Inc., Columbus, MO 65205.

Restrictions for formulating the test diets for determining protein efficiency ratio (PER) values of various protein sources for channel catfish included:

Specifications	Amounts
Protein	18%
Available energy	2,600 kcal/kg
Fat	9%
Calcium	2%
Added to all diets	
Mineral mix	2%
Vitamin mix	1.39%
Ascorbic acid	0.05%
Carboxymethyl cellulose	4%
Calcium propionate (anti-mold)	0.25%

A high calcium allowance was necessary to compensate for the high content of bone in animal and fish meals. Used in variable quantities to supply protein, energy, ash, or filler were a protein source, dextrin, cod liver oil, bone meal, and alpha cellulose. Proteins evaluated were dried catfish waste, menhaden fish meal, meat-and-bone meal, feather meal, and soybean meal.

Catfish Waste in Catfish Feeds

A pond-feeding experiment was conducted to compare growth and feed efficiency of channel catfish grown from fingerling to harvest size using pelleted diets containing either dried catfish waste or menhaden fish meal. Two moist diets were also fed, one containing raw, ground catfish waste. Each diet contained the same amount of fish protein from either catfish waste or menhaden meal, table 1. All diets were isonitrogenous and isocaloric (animal fat was added to the menhaden meal diet to make it equal to the catfish waste diets in fat percentage).

The catfish waste used in one moist diet was heated in a steam-jacket cooker under atmospheric conditions until the temperature of the waste reached 185° Fahrenheit and remained for 10 minutes. The heated and raw catfish waste were each ground through ¼- and then ⅛-inch plates in a meat grinder prior to mixing with the dry ingredients. The moist diet mixtures were extruded into 3/16-inch moist pellets, stored in hermetically sealed, 4-millimeter polyethylene bags, and stored under ambient conditions until fed. These diets were preserved by the formation of lactic acid (pH = 4.5 in 48 hours) during fermentation. The absence of oxygen in the polyethylene bags prevented mold growth.

TABLE 1. INGREDIENT COMPOSITION OF MOIST AND DRY DIETS CONTAINING CATFISH WASTE OR MARINE FISH MEAL

Ingredient	Diet	
	Catfish waste	Marine fish meal
	Pct.	*Pct.*
Catfish waste (wet)	60	—
Marine fish meal	—	15.17
Ground wheat	20.7	20.7
Soybean meal	17	17
Carboxymethyl cellulose	2	2
Vitamin mix[1]	0.4	0.4
Animal fat	—	5.1
Dicalcium phosphate	—	1.04
Water	—	38.56

[1]Vitamin premix contained the following per kg of premix: vitamin A, 1,110,000 IU; vitamin D_3, 220,000 IU; Niacin, 11,000 mg; d-Pantothenic acid, 4,040 mg; vitamin B_{12}, 4.4 mg; vitamin E, 4,400 IU; Riboflavin, 2,200 mg; Choline chloride, 2,200,000 mg; Menadione sodium bisulfate complex, 4,200 mg; Pyridoxine hydrochloride, 1,100 mg; thiamine mononitrate, 1,100 mg; Folic acid, 220 mg; Ethoxyquin, 30,000 mg; and ascorbic acid, 357 g.

The catfish waste used in the dry pelleted diet was ground, mixed with the dry ingredients, and the mixture was then dried in a convection dryer at 155° Fahrenheit for 24 hours. After drying, the material was reground through a ⅛-inch screen hammer mill and the vitamin premix was added. The two dry diets (catfish waste and menhaden meal) were pelleted into 3/16-inch diameter pellets in a laboratory pellet mill (Astro-pelleter).

The four diets were fed to triplicate ponds (0.1-acre) of channel catfish fingerlings (initial weight, 0.04 pounds each) stocked at a rate of 3,000 fish per acre for 180 days.

Another catfish feeding trial was conducted to study the effect of catfish oil versus vegetable or menhaden fish oil in the diet on flavor and frozen storage quality of processed catfish. The diets, table 2, were fed in a dry, pelleted form. The catfish waste was ground and mixed with other ingredients and the mixture was pelleted similar to the procedure followed in the previous experiment. Stocking and management of the fed fish were the same as in the first experiment. At harvest, weight gains were measured and fish from each treatment were evaluated for flavor and fatty acid composition. Fish from each dietary treatment were dressed, frozen, and stored for 3, 6, and 12 months at which times flavor and thiobarbituric acid (TBA) tests, Tarladgis (*6*), were conducted to evaluate keeping quality. Ten evaluators tasted the fish samples, which were steamed in aluminum foil for 20 minutes at 400° Fahrenheit, and assigned a score of 1 to 10 on the basis of acceptability.

TABLE 2. COMPOSITION OF EXPERIMENTAL DIETS USED TO EVALUATE THE EFFECTS OF VARIOUS OILS ON CATFISH GROWTH AND FLAVOR

Ingredient	Diet					
	1	2	3	4	5	6
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Catfish waste meal	15.0	15.0	15.0	15.0	15.0	0
Herring meal	0	0	0	0	0	11.4
Soybean meal	23.5	23.1	22.7	23.5	23.5	23.4
Peanut meal	23.6	23.0	22.7	23.6	23.6	23.4
Corn meal	28.2	32.8	37.0	28.2	28.2	29.6
Distiller's dry solids	0	0	0	0	0	0
Catfish oil	7.3	3.5	0	0	0	0
Menhaden oil	0	0	0	7.3	0	0
Soybean oil	0	0	0	0	7.3	7.3
Vitamin mix[1]	0.5	0.5	0.5	0.5	0.5	0.5
Methionine	0.2	0.2	0.2	0.2	0.2	0.04
Carboxymethyl cellulose	2.0	2.0	2.0	2.0	2.0	2.0
Dicalcium phosphate	0	0	0	0	0	2.5

[1]Same premix as shown in table 1.

Catfish Waste in Pig Feeds

Practical pig feeds were prepared in which catfish waste solids were substituted for meat-and-bone meal at levels of 6.5 and 13 percent of the feed formula. The catfish waste solids represented full-fat processing waste with only the moisture removed. They were processed by mixing the wet waste with soybean meal (to absorb the fat) and drying in a batch-type commercial dryer. Two diets containing catfish waste solids were composed with a conventional pig production diet, table 3.

TABLE 3. COMPOSITION OF SWINE DIETS CONTAINING CATFISH WASTE SOLIDS (CWS)

	Control	Low CWS	High CWS
	Pct.	*Pct.*	*Pct.*
Ingredient:			
Catfish waste solids	0	6.5	13.0
Meat-and-bone meal	6.5	0	0
Corn meal	70.3	70.0	75.7
Soybean meal	16.8	16.9	7.8
Alfalfa meal	2.5	2.5	2.5
Animal fat	3.0	1.7	0
Dicalcium phosphate	0	1.3	0
Vitamin premix[1]	.1	.1	.1
Antibiotic[2]	.1	.1	.1
Salt	.8	.8	.8
Nutrient:			
Protein	19.7	18.4	19.5
Fat	6.7	7.4	7.1
Calcium	.65	.68	.70

[1]Swine vitamin premix contains the following amounts per pound of premix: vitamin A, 1 million U.S.P.; vitamin D, 100,000 U.S.P.; Niacin, 9,000 mg; pantothenic acid, 4,000; riboflavin, 2,000 mg; folic acid, 120 mg; vitamin B_{12}, 5 mg; aureomycin, 10 g.

[2]Contains 10 g of antibiotic activity per pound.

The feeding trial was conducted at the Swine Research Unit of the Auburn University Agricultural Experiment Station. Ten feeder pigs, averaging 60 pounds each, were placed on each diet. The diets were prepared in meal form and fed to the pigs in self-feeders for a 6-week period. Weight gains were measured and the pigs were subsequently slaughtered and backfat thickness and flavor were evaluated. Ten evaluators tasted sections of the loin muscle from an animal fed each diet, and assigned scores of 1 to 10 using a hedonic scale and discriminating against fishy flavor.

A rat-feeding study was conducted to evaluate pig feeds containing wet catfish processing waste, with the presumption that swine would respond similarly to such feeds. Three moist diets were prepared, table 4: one was a conventional pig diet with water added; another contained 70 percent ground, wet catfish waste and 30 percent ground corn; and the third was similar to the catfish waste diet except it contained vitamin and mineral supplements.

Each diet was fed to 10 male weanling white rats for 28 days. The animals were housed in individual cages and allowed to feed *ad libitum*. Unconsumed food was measured once daily and replaced with fresh food.

TABLE 4. EXPERIMENTAL DIETS CONTAINING MOIST CATFISH WASTE FED TO RATS

Ingredient	Control	Catfish waste	Supplemented catfish waste
	Pct.	*Pct.*	*Pct.*
Catfish waste	—	70	70
Corn meal	78.5	30	29.6
Soybean meal	11.3	—	—
Meat-and-bone meal	6.5	—	—
Alfalfa meal	2.5	—	—
Mineral mix	0.05	—	0.05
Vitamin mix	.35	—	0.35

Catfish Waste in Pet Foods

A canned product, resembling commercially-canned dog food, was formulated containing 16 to 33 percent catfish processing waste, with similar moisture and protein contents as commercial dog food, and meeting in NRC nutrient requirements for dogs, National Research Council (5). The composition of the formulations is presented in table 5. The catfish waste was ground, mixed first with the dry ingredients and then water. The slurry was heated to 185° Fahrenheit, poured into 207 x 300 cans,

TABLE 5. INGREDIENT COMPOSITION OF CANNED PET FOODS CONTAINING CATFISH PROCESSING WASTE

	Diet		
	No. 1	No. 2	No. 3
Ingredient:			
Catfish waste	16.2	25	33
Soybean meal	15.1	8	7.5
Corn meal	2.3	11.1	9.8
Wheat bran	1.8	2.6	—
Iodized salt	.4	.4	.4
Vitamins + antioxidant	.2	.2	.2
Iron oxide	.03	.03	.03
Water	64.0	53.7	49.2
Proximate analysis:			
Moisture	77.1	70.8	72
Protein	7.3	9.7	10
Fat	1.15	2.26	2.7

sealed, and thermally processed at 245° Fahrenheit for 90 minutes.

The canned products were evaluated for physical properties (texture, appearance) and palatability to dogs. Formula 1 was not used in the dog acceptance test since its physical quality was unsatisfactory. Formulas 2 and 3 were presented, along with commercial canned dog food as a control, to six dogs by their owners in their homes. The dogs were fasted 12 hours and the two test products and the control were placed in front of them in similar containers in amounts in excess of what the dogs could consume. The amount of each product consumed in a 30-minute feeding period was measured.

RESULTS AND DISCUSSION

Chemical and Nutrient Composition

Table 6 shows proximate analysis (crude protein, crude fat, moisture, ash) plus calcium and phosphorus contents of catfish processing waste. These values vary considerably as fat content of the fish changes with season. In the fall, when the fish have been heavily fed, the fat content of the waste is high and the protein content is correspondingly low. Table 7 shows the amino acid composition of catfish processing waste and table 8 shows the fatty acid composition.

Catfish processing waste contains a relatively large amount of fat which makes drying of the waste and extraction of the fat difficult. However, the fat should be valuable as an energy rich ingredient for catfish, swine, or poultry feeds. The fatty acid composition of fat from catfish is quite unlike that from marine

TABLE 6. NUTRIENT COMPOSITION OF CATFISH PROCESSING WASTE

Product	Component	Range	Average
		Pct.	*Pct.*
Dried Waste	Protein	27 - 49	42
Dried Waste	Fat	30 - 60	35
Dried Waste	Ash	14 - 23	16
Dried Waste	Calcium	5 - 7	5.4
Dried Waste	Phosphorus	2.4 - 3.4	2.8
Wet Waste	Water	60 - 70	67

TABLE 7. ESSENTIAL AMINO ACID COMPOSITION OF CATFISH PROCESSING WASTE, MEAT-AND-BONE MEAL AND MARINE (MENHADEN) FISH MEAL

Essential amino acid[1]	Percent of protein		
	Catfish waste	Meat-and-bone meal	Menhaden meal
Arginine	6.23	6.70	5.22
Histidine	1.57	1.92	2.32
Isoleucine	3.82	3.40	3.71
Leucine	6.21	6.40	8.02
Lysine	6.06	5.2	7.58
Methionine	2.13	1.34	2.94
(Cystine)	.74	.66	1.06
Phenylalanine	3.10	3.40	3.68
Threonine	3.83	3.26	3.77
Tryptophan	.80	.52	.98
(Tyrosine)	3.04	1.58	2.61
Valine	4.53	4.50	5.87

[1]Cystine can replace part of the methionine and tyrosine can replace part of the phenylalanine.

TABLE 8. FATTY ACID COMPOSITION OF FATS FROM CATFISH WASTE, BEEF, AND MENHADEN

Fatty acid	Percent of total fat		
	Catfish	Beef	Menhaden
Saturated:			
14:0	1.7	4.0	8.0
16:0	24.4	25.0	18.0
18:0	4.7	19.0	2.0
Total	30.8	48.0	28.0
Unsaturated; short chain:			
16:1	4.4	5.0	9.0
18:1	51.0	38.0	17.0
18:2	7.2	6.0	2.0
18:3	.1	1.0	2.0
18:4	.8	—	3.0
Total	63.5	50.0	32.0
Unsaturated; long chain:			
20:3	trace	—	—
20:4	1.5	—	trace
20:5	trace	—	10.0
22:1	—	—	14.0
22:4	trace	—	—
22:5	trace	—	1.5
22:6	2.2	—	11.0
Total	3.7	0	36.5

fish (which cause objectionable "fishy" flavor when fed to fish or livestock), but more like that from farm animals, table 8, in that it is relatively low in long chain, polyunsaturated fatty acids.

The amino acid composition of catfish processing waste indicates it is a valuable source of animal protein, but should rank slightly below menhaden fish meal for being slightly low in lysine and methionine plus cystine. The protein quality of catfish waste would be expected to be lower than that of menhaden, herring, and anchovy fish meal because it contains more collagenous tissue (bone and skin) and less muscle tissue. Collagenous protein is less digestible than muscle protein.

Protein Quality

The protein efficiency ratio (PER) values for channel catfish in table 9 indicate the protein quality in catfish waste is superior to that in soybean meal, meat-and-bone meal, and feather meal, but inferior to that in menhaden fish meal. The lower quality of catfish waste protein in relation to marine fish protein is caused in part from amino acid composition and in part from the lower digestibility of the protein in catfish waste.

Value in Catfish Feeds

Experiment 1. Channel catfish grown in ponds and fed a dry, pelleted diet, in which 50 percent of the protein came from catfish waste, gained 80 percent as much weight as catfish fed an identical diet except the protein from catfish waste was substituted with protein from menhaden fish meal, table 10. A study conducted at the Southeastern Fish Cultural Laboratory at Marion, Alabama, Lovell and Dupree (3), showed a catfish diet containing 20 percent catfish waste meal produced 87 percent as much growth as one containing an equal amount of protein from menhaden meal.

TABLE 9. PROTEIN EFFICIENCY RATIO (PER) VALUES FOR FIVE PROTEIN SOURCES DETERMINED WITH CHANNEL CATFISH

Protein source	PER[1]
Fish meal: menhaden	2.48
anchovy	2.44
Catfish waste, dry	2.08
Soybean meal: 44% protein	1.70
48% protein	1.80
Meat-and-bone meal	1.64
Feather meal	.97

[1]PER = pound of weight gain/pound of protein fed.

When the catfish waste was pasteurized and fed in a moist pellet, fish growth was equal to that for fish fed the waste in a dry, pelleted diet. However, when the waste was not heated prior to feeding, fish production was significantly less than when the waste was heated, table 10. Later studies at this station, Camacho (2), indicated the reduced weight gain was caused by an antithiamine enzyme in the unheated catfish waste.

The moist diets remained in good condition for several months when stored under ambient summer temperature conditions. As long as oxygen was excluded, no mold growth occurred. The low pH (4.5) prevented bacterial decomposition. The diets containing the unheated waste became softer with some liquid exudations during storage, apparently caused by autolysis from enzymes in the catfish waste.

Experiment 2. Data in table 11 indicate when fish meal supplied only one-fourth of the protein in catfish diets, there was little difference in fish growth between a diet containing catfish waste meal and a diet containing menhaden meal (diets 4 and 6). The addition of marine (menhaden) fish oil to the catfish diet (diet 4) resulted in more fish growth than did the addition of catfish oil (diet 1) or soybean oil (diet 5). One benefit of marine fish meal over catfish waste meal may be the difference in fatty acid composition of the oil in the two meals.

TABLE 10. FISH PRODUCTION FROM DRY AND MOIST DIETS CONTAINING CATFISH WASTE AND MARINE FISH MEAL

Diet	Production[1]	Lb. feed/lb. gain
	Lb./acre	
Fish meal, pelleted feed	6,642 a	1.1
Catfish waste, pelleted feed	5,264 b	1.5
Catfish waste-cooked, moist feed	5,242 b	1.6
Catfish waste-noncooked, moist feed	4,413 c	2.1

[1]Means with the same letter are not statistically different at $P < 0.05$.

TABLE 11. FISH PRODUCTION FROM DIETS CONTAINING CATFISH WASTE MEAL (CWM), MARINE FISH MEAL, AND VARIOUS SOURCES OF OIL

Diet	Production[1]	Lb. feed/lb. gain
	Lb./acre	
1 CWM, catfish oil, 7.3%	4,025 a	1.70
2 CWM, catfish oil, 7.3%	4,240 a	1.64
3 CWM, no oil	3,973 a	1.72
4 CWM, menhaden oil, 7.3%	4,848 b	1.40
5 CWM, soybean oil, 7.3%	3,859 a	1.79
6 Fish meal, soybean oil, 7.3%	4,906 b	1.40

[1]Means with the same letter are not statistically different at $P < 0.05$.

The addition of catfish oil or soybean oil to the diet did not reduce flavor quality of the flesh of the fed fish, whereas the addition of marine (menhaden) fish oil significantly reduced flavor score, table 12. Catfish fed the marine fish oil had an objectionable "fishy" flavor whereas those fed catfish oil did not. Frozen keeping quality of dressed fish was influenced by source of dietary fat. Fish fed catfish oil or soybean oil had lower TBA values (used as a positive index of oxidation of lipids) at 3, 6, and 12 months of storage than those fed marine fish oil, table 12.

Value in Pig Feeds

Pigs fed diets containing 6.5 or 13 percent catfish waste solids grew slightly but significantly ($P<0.05$) more than pigs fed a diet containing 6.5 percent meat-and-bone meal instead of catfish waste solids, table 13. Backfat thickness was slightly greater ($P<0.05$) in the pigs fed the diet containing the higher level of catfish waste. This diet contained 3.5 percent catfish fat. However, catfish fat did not affect flavor of the pork. Flavor differences tests indicated no detectable differences between pigs fed the catfish waste meal diet and those fed the control diet.

TABLE 12. EFFECTS OF HIGH LEVEL (7.3 PERCENT) OF CATFISH, SOYBEAN, OR MARINE (MENHADEN) FISH FAT IN THE DIET ON CATFISH FLAVOR[1]

Source of dietary fat	Fresh		6 months		12 months	
	Flavor[2] score	TBA[3]	Flavor score	TBA	Flavor score	TBA
Catfish	8.0 a	0.23 a	7.6 a	0.93 a	6.2 a	0.52 a
Menhaden	6.3 b	0.20 a	4.8 a	2.26 b	5.1 b	3.15 b
Soybean	8.4 a	0.21 a	7.6 a	0.68 a	7.3 c	0.32 a

[1]Means in each column with the same letter are not statistically different at $P < 0.05$.
[2]Flavor evaluation scale: 9 = like extremely well; 7 = like moderately; 5 = neither like nor dislike; 3 = dislike moderately; 1 = dislike extremely.
[3]TBA means thiobarbituric acid titration value; the higher the value the greater the amount of oxidation.

TABLE 13. VALUE OF CATFISH WASTE SOLIDS (CWS) IN PIG FEEDS

Diet	Average gain	Dress-out	Back-fat	Flavor: different from control[1]
	Lb./day	*Pct.*	*In.*	
Control (6.5% meat meal)	1.73	71.4	1.32	
Low CWS (6.5% CWS)	1.96	72.2	1.27	N.S.
High CWS (13% CWS)	1.87	71.8	1.59	N.S.

[1]N.S. means not statistically significant at $P < 0.05$.

The catfish waste solids used in these diets contained all the fat contained in the catfish waste as it came from the processing plant. This is probably too much fat, in relation to protein, for pig feeds since backfat thickness was affected in one of the treatments in this experiment.

The rat feeding study demonstrated that rats, and presumably pigs, will consume diets containing only wet, pasteurized catfish waste (70 percent) and ground corn (30 percent) and grow well, table 14. Diet consumption and total weight gains were slightly higher for the wet, control swine diet, but this was because of large bone particles in the catfish waste which the rats did not consume. Finer grinding of the waste would probably have resulted in higher consumption rates by the rats. Protein utilization was nearly equal among all diets. The addition of a vitamin and mineral premix was unnecessary in the catfish waste-corn diet.

TABLE 14. FOOD CONSUMPTION AND GROWTH RESPONSE BY RATS FED MOIST DIETS CONTAINING CATFISH WASTE OR A SWINE DIET

Diet	Weight gain[1]	PER
	Lb.	
Catfish waste/corn	0.23 a	2.6
Catfish waste/corn/supplement	0.22 a	2.1
Control (swine diet)	0.27 b	2.3

[1]Means with the same letter are not statistically different at $P < 0.05$.

Value in Pet Foods

The canned pet food containing 16 percent catfish waste (No. 1) was too soft with poor texture and was not used in the animal acceptance test. The products containing 25 to 33 percent catfish waste (No. 2 and 3) had texture and color very similar to commercial canned dog food. The iron oxide gave the product red color. Products No. 2 and 3 were equal in palatability to the six dogs used in the test. In all tests the dogs preferred the product containing the catfish waste over the commercial counterpart. The dogs were unfamiliar with the test foods and the control. The food containing catfish waste probably contained more animal product than the control; they had a more meaty (not "fishy") odor than the control.

PRACTICAL UTILIZATION OF CATFISH WASTE

Processed into Meal

Catfish waste must be processed into a meal to be used in commercial animal or fish feeds. Several commercial reduction processes may be used to convert the waste into meal and oil. The process used in the manufacture of marine fish meal, which involves cooking, pressing out oil, water and solubles, and drying low-fat presscake and the (added back) water solubles, should be adaptable. The process used in rendering livestock and poultry by-products (which involves cooking and evaporating off water, usually under vacuum, before fat is removed) may possibly be adaptable. However, the high fat and low fiber content of catfish processing waste makes fat expulsion more difficult than in the case of poultry or livestock waste.

If 80 percent of the fat is removed before drying, the resulting meal will contain approximately 58 percent protein, 25 percent ash, and 10 percent fat. Catfish waste meal can be used in any type of feed that marine fish meal or meat-and-bone meal can be used. Catfish oil can be used in livestock, fish, or pet foods. The oil can be used in large amounts without causing "fishy" flavor in the fed species.

If catfish waste is processed by the enzyme hydrolysis method, the liquified, low-fat, bone-free protein should be dried. If this

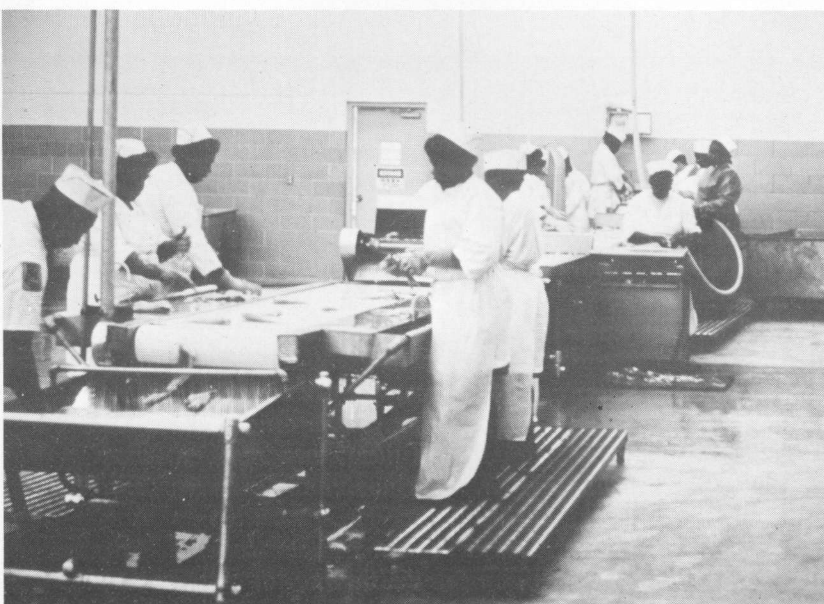

FIG. 1. Production line in a modern catfish processing plant. First the fish are beheaded (far end of line), then skinned (middle of line), then eviscerated (near end of line). The waste (heads, skin, and viscera), which is 40% of the fish entering the plant, is conveyed outside the processing room and stored until removed from the plant.

fraction is mixed back with the ground bone fraction, the resulting meal will have a similar nutrient composition as catfish waste meal made by the conventional drying process. An advantage of the hydrolysis process is that a lower temperature may possibly be used resulting in a higher quality meal. However, the lack of cooking will also cause the collagenous tissue of the head and skin to be less digestible.

Commercial Value of Catfish Waste Meal

Protein in catfish waste meal is worth more than that in meat-and-bone meal or feather meal, but less than that in marine fish (menhaden, anchovy, or herring) meal. This difference in value is caused by both amino acid composition and digestibility. Based on PER values of the protein when fed to catfish, the protein in catfish waste meal has 116 percent and 80 percent of the value of meat-and-bone meal and menhaden meal, respectively.

Catfish waste meal will be slightly higher in ash than marine fish meal and lower than meat-and-bone meal, but will be a good

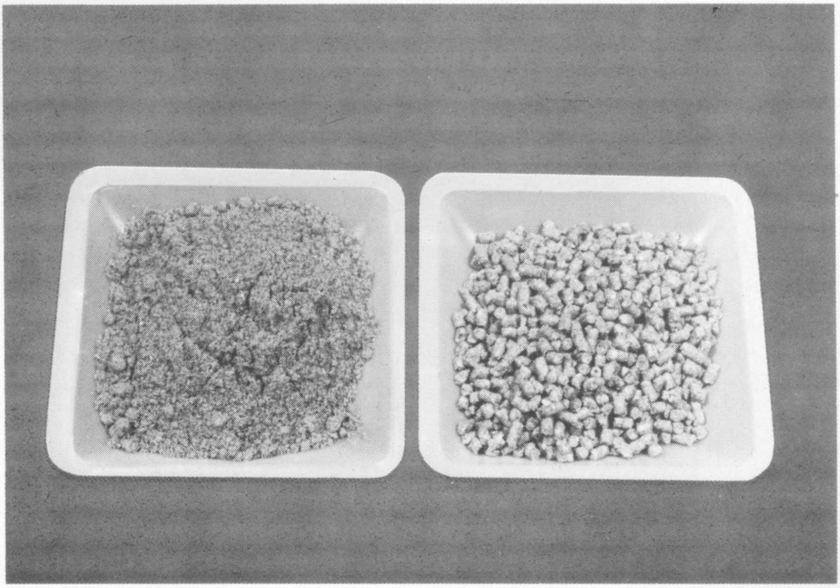

FIG. 2. Catfish waste meal processed with commercial drying equipment (left) is much like marine fish meal in appearance, but slightly inferior in nutritional value. It can be a highly valuable ingredient in commercial catfish feed (right).

source of available phosphorus, calcium, and other minerals. The oil in marine fish meal, being more unsaturated and containing omega-3 fatty acids, may have more nutritional value for fish (by supplying essential fatty acids) than catfish oil. Both sources of oil are excellent energy sources for fish and animals. Catfish oil, being more saturated, can be fed in large amounts to fish, swine, or poultry without adversely affecting flavor, whereas marine fish oil cannot.

Used in Nondried Form

Catfish processing waste can be ground, pasteurized, and included in pig feeds. Results of the rat feeding experiment indicate that rats, and presumably pigs, will eat a combination of 70 percent ground pasteurized catfish waste and 30 percent ground corn quite readily and grow well. Although the rats grew well without a vitamin or mineral supplement, over a 28-day period, a pig ration vitamin premix and supplemental zinc are recommended for a practical pig feed of this composition. If less than 70 percent catfish waste is used in pig feed, soybean meal or another protein-rich ingredient should be included to keep the protein level at 15 percent or above (on a dry matter basis).

Most state health regulations will prevent nonheated catfish waste from being fed to pigs. Heating tuna processing waste for 10 minutes at 185° Fahrenheit is adequate to render it pathogen-free prior to using in salmon diets, as practiced in the Northwestern States. Continuous-flow heat exchangers are used in processing tuna waste. Although batch type cookers can be used to heat catfish waste, a continuous-flow process would likely be more economical for handling large volumes of waste.

CONCLUSIONS

1. Catfish processing waste is composed by weight of 57 percent heads, 28 percent viscera, and 15 percent skin and represents 40 percent of the weight of the fish.
2. Catfish processing waste contains, on a moisture-free basis, an average of 42 percent protein, 35 percent fat, and 16 percent ash.
3. Protein quality of catfish waste is superior to that of meat-and-bone meal, feather meal, and all plant sources, but inferior to that of marine fish meal which is made from whole fish.
4. Catfish fat is much lower in polyunsaturated fatty acids than marine fish oil. For this reason it can be used in large amounts in diets of fish, pigs, and other food animals without imparting

"fishy" flavor or increasing the rate of lipid oxidation in frozen storage of the fed animals.

5. The high percentage of fat in catfish processing waste, which varies from highest in fall to lowest in early spring, makes drying and fat expulsion difficult.

6. Catfish processing waste can be processed by conventional fish meal reduction, or by enzyme hydrolysis with subsequent drying, into meal which has approximately 80 percent of the fat removed and will contain 58 percent protein, 25 percent ash, and 10 percent fat.

7. Wet diets containing only pasteurized catfish waste (70 percent) and corn (30 percent) produced good growth in rats and should be satisfactory for pigs. A vitamin and zinc supplement is recommended for long-term pig feeding.

8. Appearance, texture, and animal acceptance were as good in a canned dog food containing 33 percent wet catfish waste as in commercial canned dog food.

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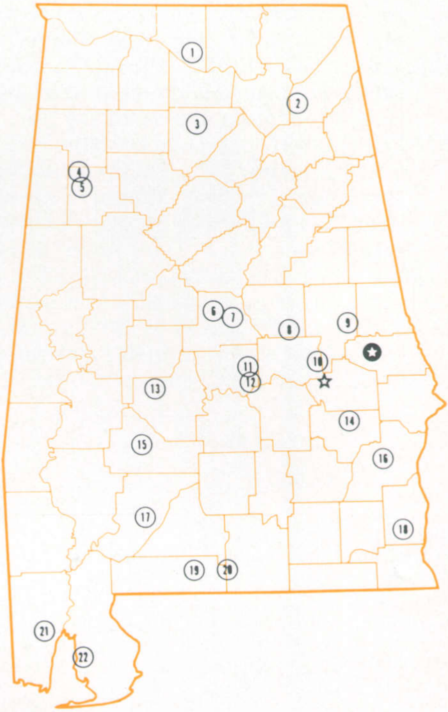

Research Unit Identification

⊛ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. The Turnipseed-Ikenberry Place, Union Springs.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Solon Dixon Forestry Education Center, Covington and Escambia counties.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.