United States Department of the Interior, J. A. Krug, Secretary
Fish and Wildlife Service, Albert M. Day, Director

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FISH REDUCTION PROCESSES

By Charles Butler*

Contents

Reduction of fish and fish waste to fish meal and fish oil has been the basis for commercial operations along our seacoasts for many years. Methods employed have changed with the gradual improvements in equipment available for adaptation to the peculiar needs of the operators and with the background of practical experience that only actual plant operation can develop. The fish processors' control over raw materials harvested from the sea is very limited even as to quantity and quality. Localized adaptations of plant equipment and day to day changes in technique of operations by plant crews have been as important as have been the original designs of factory installations. Obviously, therefore, a description, or discussion, of all the processes would be beyond the scope of this short report.

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GENERAL DISCUSSION

Fish reduction procedure depends upon (1) volume of raw material, (2) percentage of oil it contains, (3) peculiarities of the raw material, (4) quality of oil and meal produced, and (5) extent of investment. There are two general types of processes in use for fish reduction: wet reduction and dry rendering.

The wet-reduction method involves three stages of operation: cooking, pressing and drying. It is used for those fish which contain so large a proportion of oil that its recovery is profitable, and for those which are processed in very large volume. Common species of fishes so processed include menhaden, pilchards, and herring. The fish are cooked with live steam under pressure; then, pressed to expel most of the oil and some of the water; and finally, the pressed fish are dried to remove most of the remaining water. Equipment consists of a hogger or grinder (for large material), a cooker, a press, a wet-meal (press cake) disintegrator, a meal drier, and a dry-meal disintegrator.

Dry rendering is a batch operation as contrasted to the continuous process of wet reduction. Such fish materials as shark and grayfish carcasses, and miscellaneous fillet waste, are processed by this method. The fish are charged through a port to the inner of two concentric cylinders. Steam under pressure is admitted to the space between the cylinders and the heat transferred through the wall, first cooks and then dries the fish. The equipment required includes a grinder or hogger, a steam-jacketed cooker-drier with a power driven stirring device, a press (usually hydraulic type), and a press-cake disintegrator or swing-sledge mill. The cooker-drier may be operated at atmospheric pressure, or a vacuum system may be connected to facilitate removal of the moisture.

As mentioned previously, each method of reduction has its place. Dry rendering is more costly to install for the same capacity, it yields an inferior quality of oil, and the operation expense may be higher. The water-soluble materials are retained in the meal, however, and the meal yield per ton of raw material is appreciably larger. The wet-reduction equipment enables the processor to handle a large volume of material continuously, the initial expense and the operating expense are less, and a good quality oil may be obtained. The meal does not contain water-soluble materials, so the yield is lower.

APPROXIMATE COSTS AND CAPACITIES

Although units of from one- to five-ton per hour capacity are available, the most common continuous steam-cooker screw-press type of equipment usually installed has a raw material capacity of ten tons per hour. Such an installation includes the grinders, conveyors, cooker, press, drier, the oil settling tanks, sacking and meal-collecting equipment, all motors, valves, and similar equipment, but not piping and wiring. The cost f.o.b. manufacturer's plant for the ten-ton per hour plant is approximately $64,000 for the steam-tube meal drier design and $54,000 for the direct-heat drier design. A recently announced fish-scrap processing plant is designed to handle from one to two tons per hour by the wet-reduction process. Equipment is similar to that just listed except that no drier is included. The price quoted is approximately $17,000. The press-cake could be handled in either a small direct-heat or steam drier as for the ten-ton size plant, or in a single dry-rendering type batch-drier described below. The latter drier unit, complete with the grinders, conveyors, collecting and sacking assembly, and the motors, would cost approximately $22,000. If the fish scrap is wet-processed prior to the batch drying by this method, the capacity of the combined equipment may be estimated at about 24 tons of raw fish scrap per 12-hour day.

The costs for the several brands of centrifuges (used in place of settling tanks) vary somewhat, as do the capacities, but that of the sludger type approximates $10,000 to $12,000, while that of the purifier type for a large through-put capacity is about $4,500. The three settling tanks required to handle the press liquors from the ten-ton per hour plant, described above, should cost a total of about $3,000 to $3,500.

A dry-rendering system designed to process shark carcasses at the rate of 32 tons per 12-hour day is available. The installation includes four batch driers, conveyors, motors, grinders, press, and meal collecting and sacking equipment. The approximate price f.o.b. for the plant is $35,500.

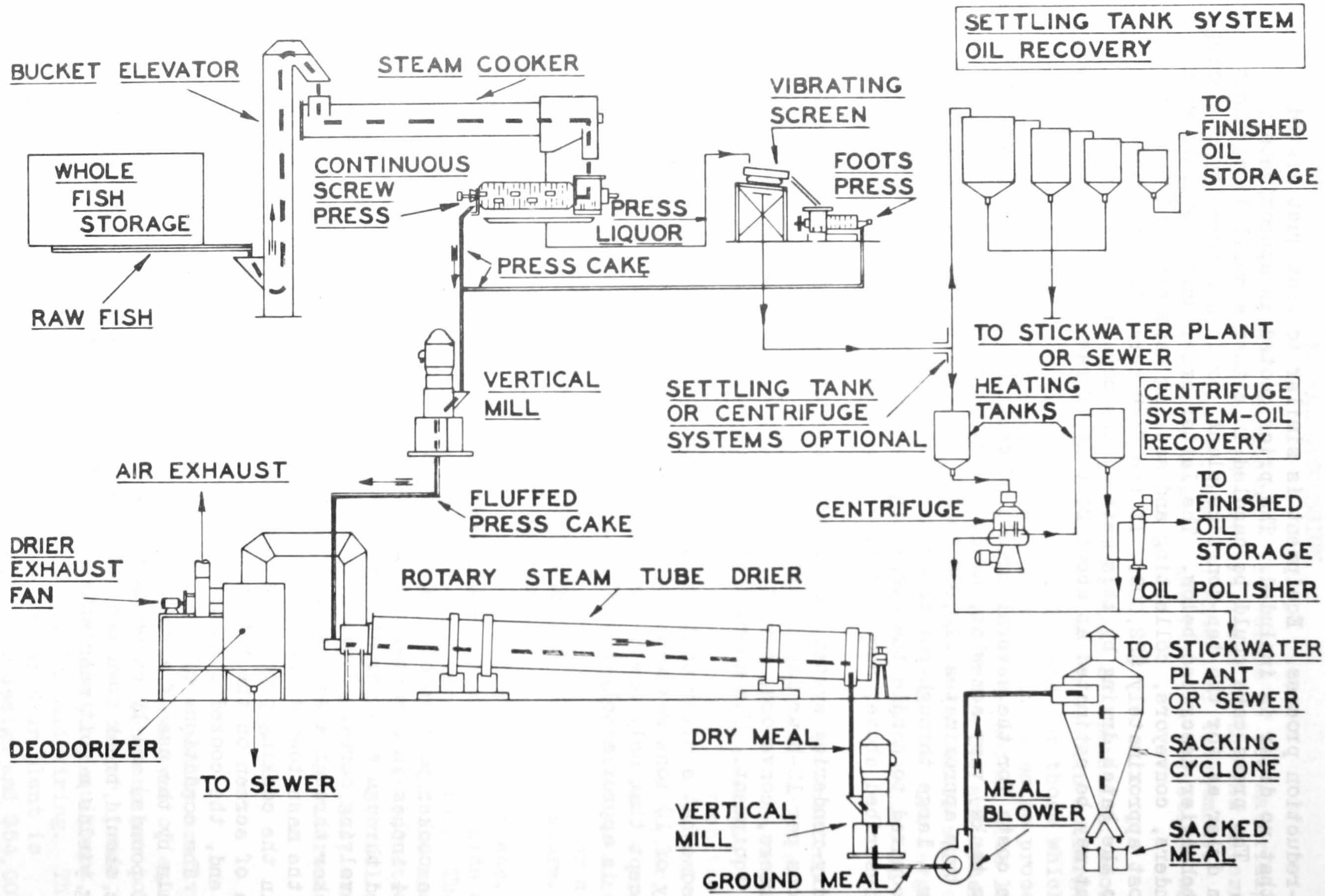
A somewhat similar unit for processing fish waste at a rated capacity of 12 tons raw material per 12 hours consists of the above equipment except that only one drier is furnished. The quoted price f.o.b. factory is approximately $25,000.

WET REDUCTION EQUIPMENT
(See Figure 1.)

Continuous Cooker

The cooker portion of a 10-ton per hour unit consists of a steel shell 24 inches in diameter and some 30 feet in length. The fish are admitted through a hopper at one end and slowly moved through the cooker by a revolving screw. Steam is introduced from a manifold paralleling the cooker through a series of jets in the cooker wall. As the screw pushes the mass toward the discharge end of the cooker any oil and water freed in the cooking process is allowed to escape through a 4- to 6-foot section of screen on the bottom half of the cooker shell. At the discharge end, the cooked fish drop through a hopper to the press directly below. The conditions of cooking may be altered to suit the varying raw materials by the use of a suitable steam pressure in the cooker (usually 5 to 10 pounds) and by changing the speed of the screw. The cooking process should break down the oil cells and coagulate the protein, but overcooking yields a soft mass which is difficult to press well.

FLOW SHEET FOR TYPICAL FISH REDUCTION PLANT



COURTESY ENTERPRISE ENGINE AND FOUNDRY COMPANY

FIGURE I.

P-7398

Continuous Press

One type of press consists of a cast-steel screw, surrounded by a cylindrical screen, suitably reinforced at intervals along the area of pressure. The screw is machined to fit tightly against the screen, and the pitch of the flights progressively decreases so that the pressure exerted becomes greater as the water and oil content of the press cake becomes less. At the discharge end a constrictor is built into the press so that by adjustment of a cone attached to the screw the size of the discharge opening, and hence the pressure developed, may be regulated to produce the desired characteristics in the press-cake. The sections of the cylindrical screen which make up the press may have perforations of approximately 3/64-inch diameter at the inlet end and of approximately 1/32-inch diameter at the discharge end. The press liquors are carried from the drip pan to the settling tanks or centrifuges for the recovery of the oil.

A press which works on a different principle consists of two, 4-foot-diameter press-wheels rotating on an angle-hub. The wheels rotate by means of ring and pinion gears, and the face of each wheel is made up of removable steel plates covered with a perforated screen. The hub is set at such an angle that the close point between the press wheels is slightly ahead of the bottom point toward the discharge side, thus giving a uniform, continuous pressing-action. The pressed cake is discharged by means of a spade protruding between the plates. The liquors are disposed of in the same manner as with the screw-type press.

Oil Recovery by Centrifuges

Centrifugal separators have been extensively used to replace settling tanks for recovery of the oils from press liquors. Several different companies have designed and manufactured centrifuges, but there are essentially only two types. One, a three-phase machine called a sludger, is designed to handle liquor containing oil, water, and some suspended solids. The solids, and part of the water, are continuously discharged through the ports in the wall of the separator bowl. Usually the machine is adjusted so that all the oil and a small amount of water are discharged at the oil spout. This adjustment insures that no oil will be lost, but does produce a wet oil or emulsion. This emulsion then is passed to the second type of centrifuge, the oil purifier, where the last traces of solids and water are removed. It is possible to adjust the sludger machine so that with careful operation an oil suitable for direct marketing may be obtained. However, there is always the possibility that oil may be lost into the water discharge in the separation process. Then, too, the processing capacity of the centrifuge is somewhat less if this technique is used. It is customary for these reasons to use the two types of centrifuges in conjunction.

Direct-Heat Drier

The drier unit consists of a dutch-oven type furnace as a source of heat, and a horizontal drier shell. For ten-ton per hour capacity the shell is approximately six feet in diameter and 50 feet in length. The drier shell is mounted on trunions; a slow rotation of the shell is accomplished by reducing the speed of the driving motor through a jack-shaft arrangement. From the jack shaft the power is applied through a gear to the bull ring attached to the shell. Wet meal is introduced by an overhead hopper or an under-feed screw conveyor. The inlet end of the drier shell is mounted to turn in a collar in the rear arch of the furnace. The products of combustion, and the additional air drawn through the dutch-oven heating area, pass through the drier parallel to the path of the fish meal. The steel plates or lifters attached to the inside wall of the drier shell cause the meal to be carried up the sides and then to be spilled continuously into the path of the hot gases. A fan draws the spent gases and the suspended fine meal through a cyclone separator, where the meal is recovered and the gases are discharged. The major portion of the dried meal is discharged from the end of the drier and it is then sent to the grinder.

Steam-Tube Drier

The steam-tube drier differs somewhat from the previously described direct-heat drier in that the heat is applied through steam tubes mounted in circles concentric and adjacent to the inside drier wall. As the drier rotates, the meal falls through the spaces between the heated pipes and a slight inclination of the drier toward the discharge end causes the meal to move in that direction. A fan and a cyclone separator may be used to collect fine particles of meal and to remove the moisture-laden air from the drier.

Air-Lift Drier

In this drier, wet press-cake is introduced into the bottom of a funnel-shaped tower about 25 feet high and $7\frac{1}{2}$ feet in diameter. At this point, upward air velocities are sufficient to entrain and bring all materials into suspension. As the material dries, it is carried through a blower to a cyclone, which separates the air and the dried product. A coal furnace, steam coils, or a combination gas and oil furnace can be used to supply the hot gases needed for drying; and, by regulating the volume of air, the gases can be made to enter the base of the tower at a temperature of 250 to 300 degrees. Under these conditions, the meal has sufficient moisture to prevent scorching. Since the low drying temperatures minimizes the formation of undesirable odors and smoke, the air-lift drier is said to need no anti-pollution control device.

Control of Odors

The moisture-laden gases drawn off after the removal of the fine meal particles contain obnoxious odors. In many localities it will be necessary to reduce the odor of the gases before they may be discharged to the outside air. The condensable portion of these gases may be treated in scrubbers; the non-condensable portion may then be burned.

DRY-RENDERING EQUIPMENT

Equipment usually used for the dry rendering of fish or fish waste is essentially a horizontal steam-jacketed cooker-drier which may be operated with or without a vacuum in the cooker chamber. Such a batch cooker-drier has dimensions of 5 feet x 20 feet in length for an approximate capacity of 4 tons of raw material per 6-hour cycle. A slow stirring of the fish mass is accomplished by agitator paddles or scrapers attached to a central shaft inside the cooker. Fish are charged through a door in the top; the dried meal is discharged through a small door at the bottom of the front end of the drier. If the dried meal contains sufficient oil to warrant recovery, this may be accomplished by means of a hydraulic press.

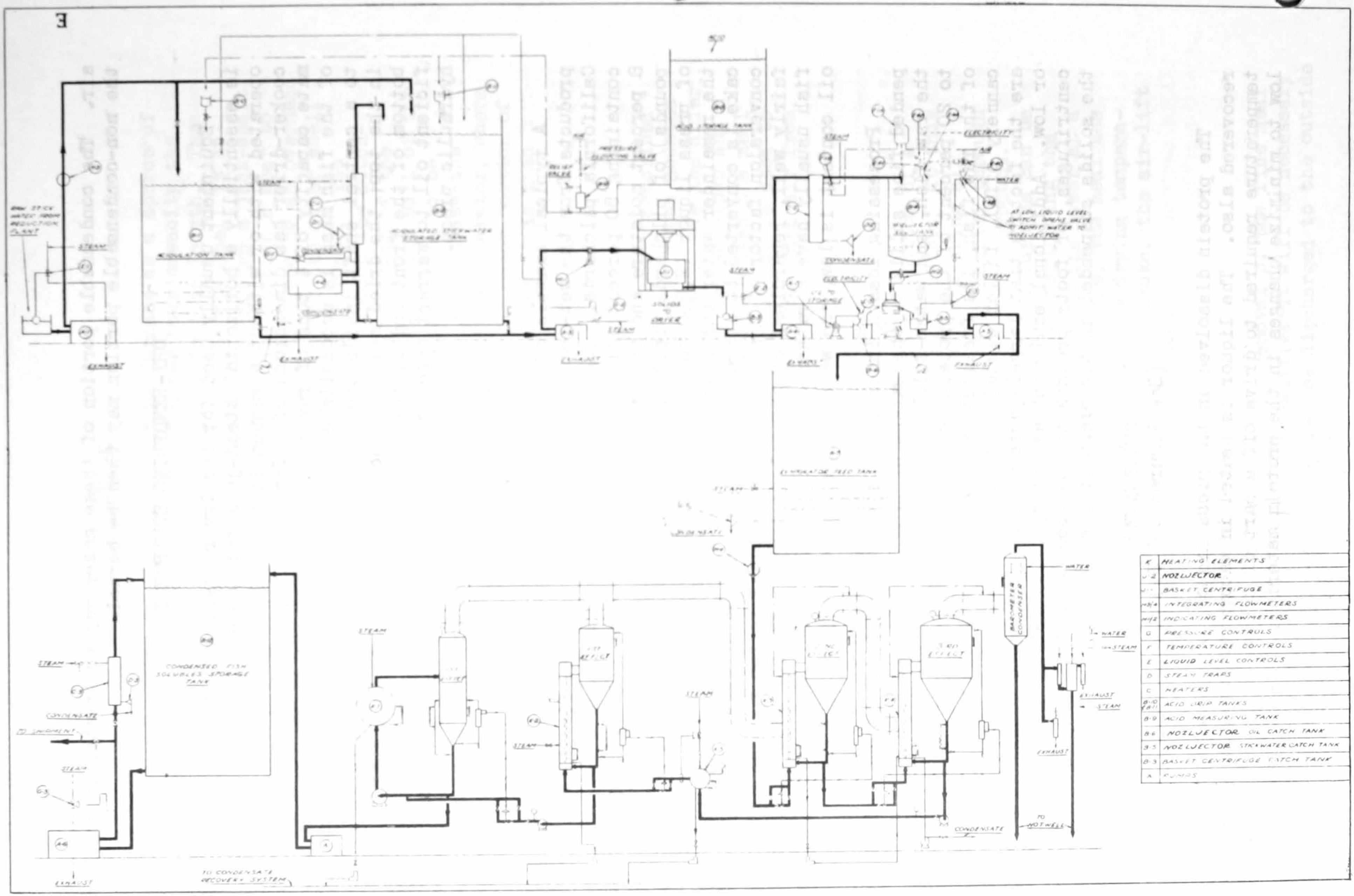
GENERAL INFORMATION

A typical example of the character and relative volume of the several products from the wet-reduction process may be cited for the handling of California pilchards. The wet-reduction process yields a wet press cake, containing 50 percent moisture and 3 percent oil. The dried meal contains 8 percent moisture and approximately 6 percent oil. Ten tons (20,000 pounds) of pilchards yield 8,000 pounds of press cake, and 16,000 pounds of press liquor (2,800 pounds of oil, 650 pounds fine protein solids, and the remainder water and dissolved protein). The 8,000 pounds of press cake is converted to approximately 4,000 pounds of meal. The customary conversion factor of ten tons of raw material to two tons of meal applies fairly well, regardless of the oil content of the raw material as the fish usually have a rather constant oil-plus-water proportion. If the oil content is low, the water content is correspondingly high.

Processing losses inherent in the wet-reduction method include suspended fine solids to the extent of from 1 to 5 percent of the weight of the raw fish, and water-soluble protein material at the rate of from 15 to 20 percent of the protein contained in the raw fish. The condition of the raw fish, its freshness and the source of the waste (whole fish, cannery offal, fillet waste), and the technique of equipment manipulation are the factors that largely determine whether these losses will be high or low. Additional equipment as rotary or vibrating screens, basket centrifuges, or foots presses may be used to increase the recovery of the solids suspended in the press liquor.

STICKWATER
(See Figures 2 & 3.)

The protein dissolved in the press liquor, or stickwater, may be recovered also. The liquor is heated in vacuum evaporators where the temperature required to drive off a part of the water is sufficiently low to minimize changes in the protein material. The stickwater is



COURTESY THE SHARPLES CORPORATION

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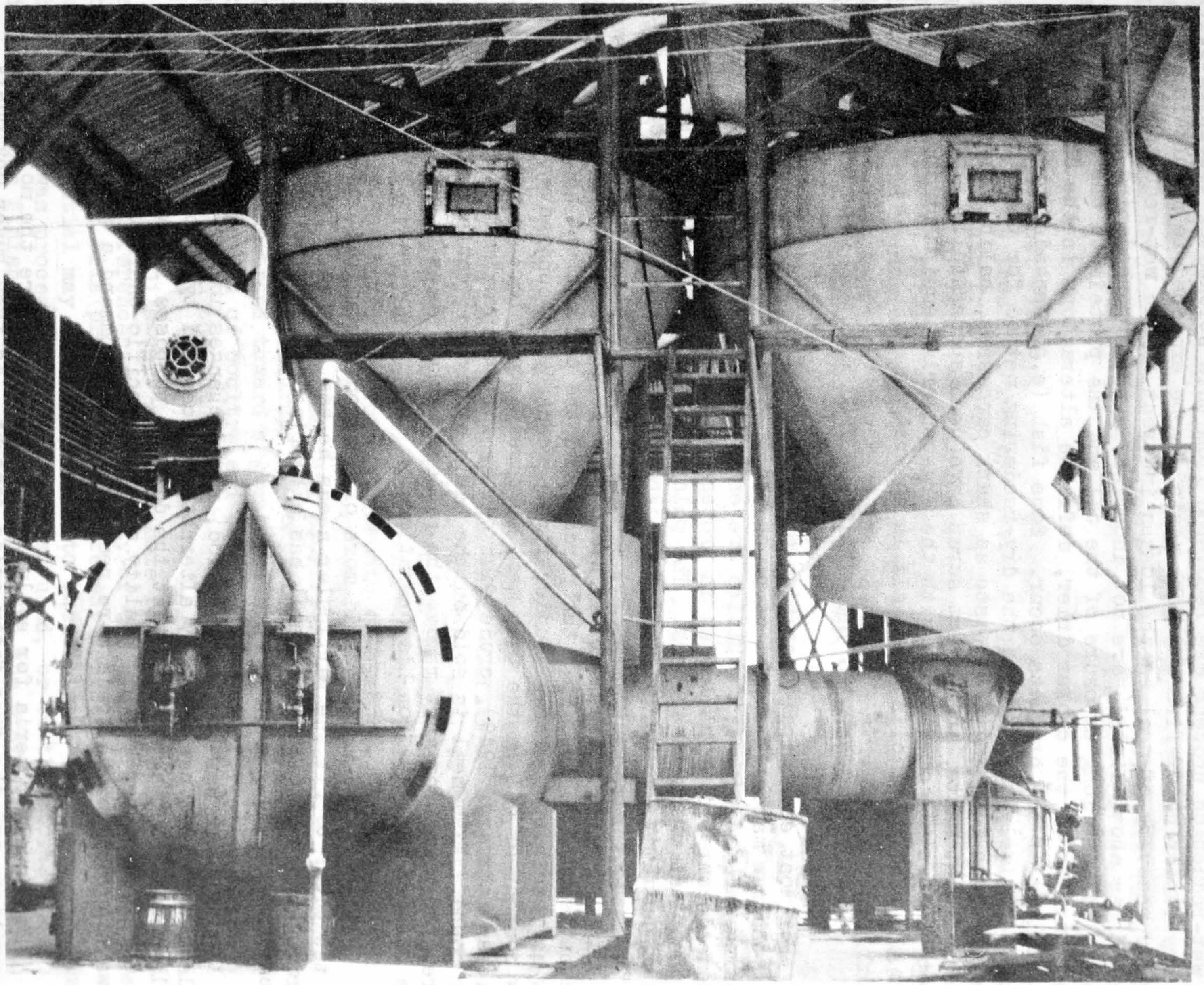
FIGURE 2.

VACUO DEHYDRATOR and SEPARATOR



COURTESY DAN B. VINCENT, INC.

FIGURE 3.

P-7398

concentrated until a product is obtained which has a content of 50 percent solids. The water-soluble B-complex vitamins removed from the fish in the wet-reduction process are recovered from this stickwater concentrate. The dry rendering of fish and fish waste may be expected to result in a greater recovery of meal as the losses inherent in the wet-reduction process, as above listed, are not incurred in the dry-rendering technique. However, in the long exposure of the oil and the protein to the heated metal surface of the cooker drier, definite alterations in the character and quality of the products occur. Some fish (e.g. menhaden) have been found peculiarly unsuited to the dry-rendering method for these reasons. However, such fish and fish waste as shark carcasses, halibut and salmon heads, fillet waste, and market scrap have been successfully processed. Pilot plant-scale operations with the dry-rendering equipment indicate that the quality of oils and meals is acceptable.

FACTORS GOVERNING THE QUALITY OF FISH MEAL AND OIL

For most economical operation and for excellent quality fish meal and oil, the raw material should be processed in as fresh a state as possible. Cooking and pressing difficulties are encountered when the fish have become decomposed. The losses in processing are increased and the quality of the final products suffers. The palatability, and very probably the actual nutritive value, of meal from decomposed material is lowered.

In order that fish meal may stand up well in storage, the moisture content should be less than ten percent and the oil content should be as low as possible, preferably under five percent. A second advantage of a low content of oil in the fish meal is purely economic. At present prices (February, 1949), crude fish oil is worth approximately 11 cents per pound. Fish meal is sold on the basis of protein content only; therefore, the processor must remove the oil and market it as oil if he desires the largest revenue from his operations.

Fish oils are usually sold more or less on specifications drawn up by the buyer to fit the particular needs he has in mind. The supply of various types of oils in general has a bearing on how exacting the specifications may be.

During the war-emergency period, rapid changes in supplies of all oils have forced users to try alternate sources and types of oil. Fish oils have thus benefited in that the diverse purposes for which they can be used are better known. Quality oils of specific characteristics will always move into the trade more readily and may command a premium price as well.

The usual criteria for evaluation of fish oils are the moisture, impurities, and the free fatty acids content. As they buyer obviously cannot use water or solids purchased as oil, he usually stipulates that it contains not more than one percent moisture and impurities, and he may claim reimbursement for freight charges on that portion of the shipment in excess of that amount. In other cases, if a relatively "moisture- and solids-free" oil is specified, he may refuse delivery if a certain maximum is exceeded. The stipulated content of free fatty acids in the oil largely depends upon the end use of the oil. Most contracts call for a maximum of from one to two percent free fatty acids content expressed as oleic acid.

In order to meet exacting specifications, the processor must handle the raw materials in as fresh a state as possible. He must remove the moisture and suspended protein from the oil with as little damage as possible to the oil from prolonged or repeated heating or cooking periods. The use of centrifugals in the purification of fish oils has made possible more efficient oil recovery and an improved initial quality of oil. The storage life of such higher quality oils has been considerably increased over that expected from oils prepared by the older settling-tank methods.

FISH MEAL AND OIL PRICES

The prices which may be obtained for fish meal and oil are governed, as in the case of most commodities, by the supply and demand. During times of short supply the quality of the products becomes somewhat less important. On a normal market, however, the meal or oil of top quality will be purchased in preference to inferior materials even though no actual premium price is offered.

Fish meal prices are based primarily on the unit percentage of protein per ton as determined by analysis. An example will illustrate how this method is applied. On March 20, 1947 the price of fish meal quoted at Seattle, Washington, was $2.10 per unit. The fish meal to be sold has been found by analysis to contain 68 percent protein. The price per ton for this fish meal f.o.b. the seller's plant would be $2.10 (price per unit protein) X 68 (units of protein present) or $142.80. Protein content is the criterion for evaluating fish meal because practically all the meal produced goes into the animal and poultry feeding trade. Fish meals constitute one of the best sources of completely balanced protein for these rations. The trend toward a greater usage of pre-mixed feeds to increase the production of poultry and eggs augurs well for a continued demand for fish meal in the future.

Prices for fish oils vary somewhat more for any given season because there are wider differences in the quality of the product and the specific characteristics of oils produced from different species of fish. The quality differential may be attributable to the state of raw material from which the oil was processed, to the process used, or to the storage conditions for the finished oil as was mentioned in the previous section. The differences with species may be important in determining the use to which the oil may be put. Pilchard oil has an iodine value of 175-185, indicating a higher degree of unsaturation than herring oil with an iodine value of 120-150. A buyer seeking an oil with good drying characteristics for use in the manufacture of paints, waterproof coatings, linoleum, etc. would find pilchard oil more desirable. If herring oil were to be similarly employed the lower unsaturation characteristic which results in very slow drying would be less desirable. For other uses the reverse conditions may be true.

In recent years the technological advances in deodorization, hydrogenation, and fractionation processes have broadened the field of applications for fish oils in two ways: (1) Oils may be adapted by those processes to conform to the characteristics required for a specific use, and (2) during periods of oil shortages manufacturers were forced to try different types of oils. They have, in some industries, developed formulas in which any one of several types of oils may be used interchangeably without seriously altering the character, cost, or quality of the final product. These developments account, in part, for the fact that the relative position of fish oils has continued to improve. World-wide dislocation of oil and fat production from other sources during the war period also contributed to the improvement.

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Fish Meal: Average Wholesale Price Per Ton, Bagged, Los Angeles, Calif.
65 Percent Protein California Sardine Meal

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Av.
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
1935-36	33.40	36.00	34.90	36.40	38.00	36.50	36.50	38.25	40.55	40.50	40.50	43.85	37.95
1936-37	41.70	39.55	43.55	48.10	52.10	51.25	51.40	50.25	47.60	43.75	41.25	39.75	45.85
1937-38	38.75	40.35	39.10	41.95	42.45	45.05	46.50	45.85	45.30	45.50	42.80	36.90	42.54
1938-39	38.85	41.10	42.75	43.30	41.05	40.40	42.25	42.90	45.30	43.65	42.40	53.55	43.12
1939-40	55.35	53.25	51.60	52.85	52.20	51.80	52.00	54.00	54.00	51.50	48.75	46.40	51.98
1940-41	45.40	45.70	46.40	49.70	54.30	57.00	68.00	72.25	76.60	79.00	77.00	70.30	61.80
1941-42	65.80	61.90	68.20	75.55	74.75	75.00	75.50	75.50	75.50	77.00	77.50	77.50	73.31
1942-43	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50
1943-44	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50
1944-45	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50	77.50
1945-46	77.50	77.50	77.50	77.50	77.50	77.50	77.50	85.00	87.50	87.50	87.50	87.70	81.48
1946-47	170.50	169.00	164.90	167.05	162.50	163.30	162.50	154.80	153.10	153.35	154.80	162.50	161.53
1947-48	158.30	166.95	178.10	186.05	181.60	160.75	150.70	143.40	146.65	145.90	130.55	122.00	155.91
1948-49	111.70	130.85	144.10	146.00	173.85								

Source: Department of Agriculture.

P-7398

Fish Meal: Average Wholesale Price Per Ton, Bagged, San Francisco, Calif.
67 Percent Protein California Sardine Meal

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Av.
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
1933-34:	35.60:	36.65:	37.50:	37.00:	36.75:	36.75:	39.00:	39.00:	39.00:	38.60:	34.65:	35.00:	37.12
1934-35:	35.00:	34.75:	33.45:	30.40:	30.05:	30.45:	30.00:	28.90:	27.05:	25.60:	24.90:	26.90:	29.79
1935-36:	31.50:	32.50:	32.00:	32.90:	34.50:	35.70:	36.40:	38.15:	41.00:	42.00:	38.75:	38.60:	36.17
1936-37:	36.50:	35.35:	41.05:	47.75:	52.75:	52.70:	52.50:	52.50:	48.80:	41.90:	37.90:	37.10:	44.73
1937-38:	35.25:	35.75:	36.20:	43.40:	48.05:	49.10:	47.25:	45.20:	45.00:	45.10:	42.30:	37.10:	42.48
1938-39:	37.50:	39.75:	42.00:	41.10:	40.00:	40.10:	40.25:	43.10:	45.75:	45.75:	43.33:	52.15:	42.56
1939-40:	53.00:	49.60:	48.50:	53.35:	52.25:	51.45:	51.35:	55.25:	54.55:	52.50:	45.75:	46.90:	51.20
1940-41:	45.20:	47.00:	47.20:	51.25:	56.15:	60.60:	70.40:	73.75:	74.60:	75.20:	68.90:	67.80:	61.50
1941-42:	66.40:	62.25:	67.45:	75.95:	77.40:	77.50:	77.50:	77.50:	77.50:	77.50:	79.00:	79.50:	74.62
1942-43:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50
1943-44:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50
1944-45:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50
1945-46:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	79.50:	87.00:	89.50:	89.50:	89.50:	89.50:	83.45
1946-47:	127.50:	180.60:	173.55:	167.50:	167.50:	162.50:	167.50:	150.75:	148.65:	150.75:	150.75:	166.75:	159.53
1947-48:	172.95:	172.50:	183.60:	190.95:	185.10:	159.15:	155.35:	155.80:	158.80:	151.60:	136.00:	136.50:	163.19
1948-49:	128.55:	146.65:	164.15:	170.00:	188.00:								

Source: Department of Agriculture.

Fish Meal: Average Wholesale Price Per Ton, Bagged, Portland, Ore.
70 Percent Protein Herring Meal

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Av.
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
1935-36:	38.15:	40.50:	38.20:	38.00:	40.00:	40.60:	40.00:	41.25:	46.80:	36.50:	37.40:	46.90:	40.35
1936-37:	47.50:	43.00:	46.10:	53.00:	57.75:	57.70:	57.50:	57.50:	53.00:	46.00:	42.00:	42.00:	50.25
1937-38:	38.40:	39.00:	39.00:	47.00:	47.75:	49.00:	48.00:	46.80:	45.00:	45.00:	41.20:	37.50:	43.55
1938-39:	40.40:	42.00:	47.25:	48.80:	48.50:	46.25:	48.90:	51.00:	44.50:	40.00:	40.00:	57.75:	46.80
1939-40:	59.20:	60.00:	59.75:	60.40:	61.25:	55.50:	55.90:	56.50:	56.50:	54.60:	47.40:	53.00:	56.65
1940-41:	52.80:	54.90:	57.50:	58.50:	63.00:	66.25:	76.00:	79.00:	78.25:	75.80:	74.50:	76.80:	67.75
1941-42:	79.50:	69.50:	74.40:	82.35:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	80.45
1942-43:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50
1943-44:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50
1944-45:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50
1945-46:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	82.50:	90.00:	92.50:	200.00:	105.00:	105.00:	97.50
1946-47:	152.50:	175.20:	184.25:	187.80*:	183.40*:	182.25*:	182.50*:	176.10*:	164.20*:	152.90*:	157.00*:	178.60:	173.06
1947-48:	173.95:	171.00:	186.55:	201.90:	191.10:	160.00:	160.00:	160.00:	160.00:	148.75:	135.50:	133.75:	165.21
1948-49:	134.50:	141.70:	158.60:	170.30:	188.00:								

* 73 Percent Protein.
Prices for period 1942-46 are ceiling prices.
Source: Department of Agriculture.

P-7398

Average Price Per Gallon For Various Fish Oils
1933 - 1947

Year	Menhaden Gallons	Menhaden Value	Menhaden Av.	Pilchard Gallons	Pilchard Value	Pilchard Av.	Herring Gallons	Herring Value	Herring Av.
			¢			¢			¢
1933	3,344,343	$ 450,970	.13	10,263,776	$1,593,088	.16	3,174,212	$402,157	.13
1934	3,612,364	705,657	.20	20,845,171	4,413,609	.21	3,772,099	641,839	.17
1935	4,066,159	1,178,337	.29	21,735,165	6,658,965	.31	3,856,545	1,122,202	.29
1936	4,880,879	1,249,708	.26	26,131,439	8,336,079	.32	3,796,586	954,706	.25
1937	3,895,613	1,456,333	.37	15,993,216	6,203,616	.39	5,623,045	2,114,548	.38
1938	4,189,129	1,173,667	.28	17,539,567	5,205,337	.30	4,579,565	1,298,837	.28
1939	6,005,414	1,624,024	.27	19,996,422	6,078,317	.30	4,847,512	1,157,418	.24
1940	5,774,671	1,304,720	.22	12,626,849	3,761,160	.30	2,241,169	606,722	.27
1941	6,034,050	2,829,441	.47	18,125,147	9,879,290	.54	3,041,315	1,563,545	.51
1942	5,128,760	3,200,129	.62	12,508,958	8,067,750	.64	985,403	646,565	.66
1943	5,734,668	3,892,142	.68	13,947,295	9,301,593	.67	1,727,441	1,129,446	.65
1944	6,067,111	3,725,498	.61	18,098,982	11,722,950	.65	2,389,287	1,603,078	.67
1945	8,335,094	5,656,550	.68	11,852,994	7,926,147	.67	2,663,546	1,786,040	.67
1946	9,758,648	9,033,032	.93	4,866,567	6,843,376	1.41	3,532,454	4,292,776	1.22
1947	8,473,371	11,425,497	1.35	2,103,965	2,677,453	1.27	3,875,024	4,144,643	1.07

Note: These data were obtained from reports submitted by producers of fish oils. The prices are based on the amount received for oils sold during the year and estimates of the amount that will be received for any stocks remaining unsold at the time the report was submitted.