Commission of Conservation
CANADA

COMMITTEE ON FISHERIES, GAME AND FUR-BEARING ANIMALS

Utilization of Fish Waste in Canada

BY
J. B. FEILDING

OTTAWA—1918

Commission of Conservation

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Foreword

An investigation into the subject of the utilization of fish waste in Canada was undertaken for the Commission of Conservation by Mr. J. B. Feilding, who was authorized on October 2, 1916, to 'undertake work of an experimental character to determine the possibility of producing stock food and various valuable by-products from fish' caught in the Great lakes. It was at first proposed to conduct the experiments on Georgian bay, but, for various reasons, it was decided that Port Dover, on lake Erie, would be more suitable. The investigation covered a period of two months and was made at the latter place. The report which follows is Mr. Feilding's account of what was accomplished. The figures regarding cost of production appended to the report under the heading "Approximate Costs" were supplied at a later date by Mr. Feilding.

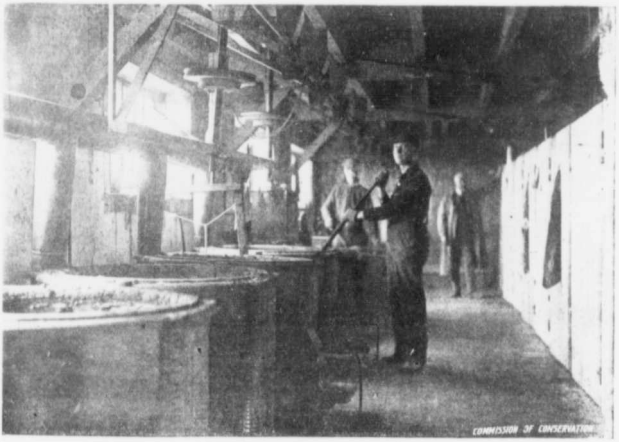
The Commission wishes to express its appreciation of the assistance rendered by, and courtesies received from, Hon. F. G. Macdiarmid, Minister of Public Works, Ontario, the late Mr. A. Sheriff, Deputy Minister of Game and Fisheries, Ontario, Mr. D. McDonald, Superintendent of Game and Fisheries, Ontario; from the following members of the staff of the Central Experimental Farm, Ottawa, Mr. J. H. Grisdale, Director, Dr. Frank T. Shutt, Assistant Director and Dominion Chemist; Mr. E. S. Archibald, Dominion Animal Husbandman and Mr. F. C. Elford, Dominion Poultry Husbandman. The Commission is also indebted to Prof. J. W. Bain, B.A. Sc., of Toronto University, for the use of his laboratory.

JAMES WHITE,

Assistant to Chairman, and Deputy Head

Ottawa, April 24, 1918.

Some of the Refuse from which Valuable Material was Secured, Port Dover, Ont.



Rendering Room where the Fish Waste was Treated to Separate the Valuable Oil Content, Port Dover, Ont.

Utilization of Fish Waste in Canada

By

J. B. FEILDING

THE utilization of fish scrap in agriculture has been in vogue for centuries in many maritime countries. It is said that the Indians, before the advent of white men, used large quantities for fertilizing purposes in this country. While serving the British Government in the Malay States some twenty years ago, I found it the common practice to make use of fish, both as a fertilizer for the soil and a food for pigs, in many of the Chinese villages having access to large fishing areas. These practices had been handed down for generations. In the Shetland isles and west coast of Scotland, I have known surplus fish to be fed to both sheep and pigs. Doubtless, in these days, there is no surplus.

As for America, we hear of a fish-rendering factory being erected as far back as 1850 on Shelter island, New York, but, in all probability, the products manufactured were only oil and fertilizer; and, in fact, so far as this continent is concerned, fish scrap is converted only into fertilizer, except otherwise, perhaps, in a very small way.

It is in Germany we have to look for knowledge of the early using of fish waste as live-stock feed, and it was in that country, some eighteen years ago I studied the problem myself, though my work was entirely confined at that time to the manufacture of fish-waste products. Much useful investigation since that time has been done on the European continent and also in England.

In Germany, we find Lehmann stated in 1892, that fish meal ranks with meat meal and that laboratory results show that 98.6 per cent of the protein is digestible. Fink, in 1896, stated that he finished off steers on fish meal with other feeds, giving them 3 lbs. per day each, and as a result he obtained a gain of 303 lbs. in 90 days. Schenk, in 1903, conducted a very exhaustive series of experiments and, with other investigators, came to the conclusion that herbivorous live-stock were able to make better use of the protein in fish meal than they were of protein of vegetable origin. These investigators found fish meal universally an economic feed of very high value and that it left no taint with either milk, butter, bacon or eggs when fed in reasonable quantities on the farm. Martinelli, as reported in the Journal of the International Institute of Agriculture, states that animals fed on fish meal made more rapid gains than on meat meal, and not only that, but they were of superior quality.

The results of an interesting experiment conducted at the Agricultural College at Seal Hayne are reported in the Journal of the Board of Agriculture and Fisheries (England), 1914. In one of the experiments, it is pointed out that the substitution of fish meal for various other foods fed to pigs resulted in increased profits amounting in one series to 42 per cent, and in another to 94 per cent, notwithstanding the fact that the ration was higher in cost. In another experiment, fish meal was fed to cattle without any harmful results.

The rations of fish meal of North Sea origin as recommended by several authorities are: for cattle, 2 lbs. per 1,000 lbs. live weight; pigs, ½ lb. per 100 lbs. live weight; sheep, ¼ to ½ lb. per 200 lbs. live weight; while poultry can assimilate a ration containing 10 per cent fish meal.

From my own observations over a period of some twenty years, I can testify to its general use in Europe without harm to any of the usual live-stock on the farm. I have, personally, for many years used meals (compounded) for the raising of fish in fish-breeding establishments with the most satisfactory results.

By far the most important modern contribution to literature on the subject of the use of fish meal as a feed is contained in United States Agricultural Bulletin No. 378, the work of Mr. F. C. Weber, to whom we are greatly indebted. Mr. Weber appears to have collected abundant evidence as to the suitability and economic use of fish meal as a farm live-stock feed. He gives the following as the average analysis of some six meals used in his experiments:

	Per cent
Water	4.74
Ash	16.68
Total nitrogen	9.68
Protein	60.50
Fat	14.56
Crude fibre	0.61
Salt	5.78

In Mr. Weber's conclusion, he states that he is justified in saying that fish meal 'is a very effective supplement to a grain ration for pigs. . . . . In this experiment, fish meal was superior to tankage in all comparisons.' Dairy cows fed on a ration of fish meal compared with cows fed on a similar ration in which fish meal was replaced by cotton-seed meal, gave a greater yield of milk, but it contained a lower percentage of butter fat. However, the total amount of fat obtained was approximately the same in both cases.

Mr. I. W. Turrentine, of the United States Bureau of Soils, has, during the last few years, published the results of some interesting and

very valuable investigations relative to the utilization of fish waste as a fertilizer. In one Bulletin, No. 50, United States Department of Agriculture, he re-affirms what many other investigators of agricultural economy have stated, namely:

'It should be pointed out here that, with such fertilizing materials as dried blood, tankage, cotton-seed meal and fish scrap, it is better agricultural practice to feed these to stock . . . . . than to apply them direct to the soil. It can be taken as thoroughly well established that both the nitrogen and the phosphoric acid, after performing their rôle in the life processes of the adult animal, are eliminated. Then the high food value of these rich foods is utilized and at the same time the fertilizing elements are still available for use on the growing crops.'

Quantity of Fish Waste in Canada

With regard to the availability of fish waste in Canada, I am only in a position to offer an estimate, but, after conversing with many in the fishing industry, I feel sure I am not over-estimating when I place the quantity at something like 250,000 tons a year.

A few examples of waste may be useful as illustrating my assumption. It is stated authoritatively that it requires 88 lbs. of salmon on the Pacific coast to fill 48 one-pound cans; the balance, about 46 per cent, is waste. In the British Columbia salmon packing industry alone, it is estimated there is annually some 20,000 tons of waste. In the lobster packing industry, the percentage of waste is 75 per cent. In the Atlantic dry-fish curing industry, 45 per cent is waste. On the Great lakes, 44 per cent. of the total annual catch is waste.

Fishermen generally will inform one that, of the total catch of all species of fish caught at sea or on lake, 25 per cent consists of fish of no market value, and, further, of the remaining 75 per cent, an additional 25 per cent can be deducted as waste on gutting for market. In the halibut fishery, the head is the only waste brought ashore and it is estimated to be one-sixth of the weight of the 'cleaned' fish. It will be readily understood that, whatever the quantity of waste is, it is colossal.

The outstanding question, then, is how much of this waste is economically collectable and convertible. This is a factor for further investigation.

Obviously, the chief points of collection will be found on the two sea coasts.

Preparations for Experimenting

It was thought wise so late in the year (October) to commence investigations on the waste originating in the inland waters, where, it is

estimated, there is probably 8,000 to 10,000 tons of waste, an amount of material now being buried annually, or otherwise destroyed. With this in view, I got into communication with the Deputy Minister of Game and Fisheries for Ontario, who kindly offered me every facility.

Before commencing my work, I had to ascertain whether the facilities on Georgian bay or lake Erie would best be suited to my work. It was decided to open a small research station at Port Dover on lake Erie, in view of the fact that I had not only natural gas at my disposal, but also—the all important factor—a certainty of supply of such raw material as I required.

After selecting a site, I proceeded to ascertain what apparatus was available. In this I found great difficulty, for, on all sides, I was told nothing could be made or even adapted to my purpose for several weeks, and possibly months. I had, therefore, to content myself with four ordinary feed cookers which, of course, could only be operated at a maximum temperature of 212° F., so far as digesting was concerned.

For drying purposes I had to content myself with direct gas-fire heat without circulation, and for moulding, I had to use an Enterprise chopper. All other apparatus was on similar makeshift lines.

However, I had to make the best of the apparatus available and I am glad to say that I found it fairly capable of showing me approximately what was obtainable from the waste in a qualitative way.

On arrival at Port Dover, I had some difficulty in leasing suitable premises, but eventually secured part of an old tannery very much out of repair. In this, I erected what plant and machinery I could collect in the time and I subsequently engaged a man and boy to assist me in the work.

I then entered into an arrangement with the fishermen to supply me free of cost with such waste as I required, and, as a result, I took in for treatment and research about half a ton of raw material every other day.

Character of Feeds Manufactured

The waste I found very different from the material which I had had previous experience with in other countries, particularly on the North sea, and necessitated much more careful treatment than my make-shift apparatus permitted. However, with certain data in my possession, I proceeded to compound various live-stock feeds along the lines I had previously operated, some eighteen years ago, in Germany. These feeds were used experimentally at the Central Experimental Farm at Ottawa.* I fear I was unable, with the plant at my disposal, to extract

* See p. 14 for feeding experiments conducted at the Central Experimental Farm.

as much oil as I should have liked from the waste, which may result in the meal being too rich in fats, and further, such being the case, the feeds may change chemically through the generation of fatty acids, and thus become unpalatable. There is no doubt, however, that the material could, with suitable machinery, be made into exceedingly valuable feeding materials for the farm, if the raw material, namely, fish waste, can in every case, be obtained fresh.

In my opinion, this fish meal can be made at a cost that would admit of a fair profit to the manufacturer, assuming the waste were obtained free or at nominal cost.

From former experience, I have satisfied myself that fish meal, as such, being the dried residue with all freely-extracted oil withdrawn, must be compounded with 'mill offals' and other materials in order to prevent it chemically breaking down within reasonable time. The meal appears to be somewhat hygroscopic and, owing to its animal origin, it is easily influenced by climatic conditions.

The commodities manufactured must vary according to the type of waste used, and the purpose to which the finished product is to be put. No definite formulæ at this stage of the research can be stated as applicable to this fresh-water fish waste, until the keeping and feeding qualities have been tried out over an extended period.

There is no doubt, however, that satisfactory results can be eventually attained, but much more experience and further research must be applied, since this type of waste varies in composition almost every month of the year.

The types of feeds I compounded were:

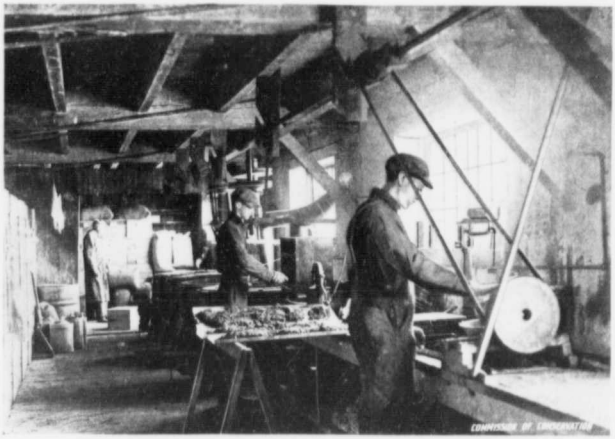
1. Cattle meal, 75 per cent fish meal.
2. Hog feed (cooked), 75 per cent fish meal.
3. Poultry scratch feed, 10 per cent fish meal.
4. Dog biscuit (baked), 25 per cent fish meal.

I am much indebted to Dr. Frank T. Shutt, the Dominion Chemist, for his chemical analyses of both raw material and other products of my work. The analyses forwarded by Dr. Shutt are as under:

FISH MEAL FEEDS

ANALYSIS OF PRODUCTS BY DR. FRANK T. SHUTT, DOMINION CHEMIST

Lab. No.	Ident. No.	Designation	Water	Protein	Fat	Carbo-hyd-rates	Fibre	Ash	Fertilizing constituents		
									Nitro-gen	Phosphoric acid	
										As phos. acid	As phos. of lime
28533	XS. ix P.D.	Fish Waste '(viscera and content)	2.92	54.38	26.91	7.67	.81	7.31	8.70	3.06	6.68
28535	.....	Fish Meal (whole fish)	2.10	61.88	20.34	2.98	.70	12.00	9.90	4.82	10.53
28534	No. 10	Hog feed concentrate	1.88	49.07	15.70	11.77	3.44	18.14	7.85	4.53	9.90
28537	No. 13	Poultry scratch food	5.81	25.55	8.95	43.95	6.96	8.78	4.09	2.31	5.05
28538	No. 12	Cattle feed concentrate	12.20	39.13	11.00	19.39	3.17	15.11	6.26	4.00	8.74
28673	No. 12 P.D.	Hog feed concentrate	3.99	53.54	17.33	11.32	1.84	11.98	8.57	4.23	9.24
28674	No. 15	Poultry scratch food	2.66	17.86	4.20	58.82	9.72	6.74	2.86	2.19	4.78



Grinding and Compounding Fish Waste Products, Port Dover, Ont.

Laboratory, Port Dover, Ont.

I estimate the market values of these feeds, in normal times, to be as follows: the cattle feed, $40 per ton; hog feed, $50 per ton; poultry feed, $45 per ton and the dog biscuit, $100 per ton.

For comparison it may be of interest to quote recent prices (April, 1917) given me by some leading manufacturers and dealers of other protein concentrates now used by farmers in this country:

	Protein	*Price*	
Linseed cake meal	40 per cent	$54	f.o.b., Toronto
Cotton cake meal	20 to 24 per cent	$40	" "
Tankage	60 per cent	$65	" "

Besides the experimental feeding being conducted by the Central Experimental Farm, I, myself, tried a ton on my own farm. Being absent from home on this investigation, I could not conduct the experiment on the usual lines, but, in any case, my chief object was to ascertain if this fresh-water fish waste was as attractive to live-stock as salt-water waste of which I have had previous experience. As a result, I have no hesitation in saying that all stock fed on this material properly compounded did well and relished it. I fed it to 20 head of cattle, 20 head of pigs and about 100 poultry. Further, I fattened off one 'beast' on fish meal and bran and sold him at 8¼ cents per pound on the hoof.

I am, therefore, satisfied that fresh-water fish waste properly made up is a suitable and economic protein and fat concentrate for all farm live-stock.

Oil

So much for the utilization of the dry residue of fish waste. The other economic product obtained is oil. This I found varied both in quantity and quality in relation to the type of waste brought into port.

Some days the waste would consist chiefly of lake herring viscera, while on others, of whole fish, chiefly eel pouts (*lota maculosa*) and small blue pickerel (*stizostedion canadense*) that had been 'bridled'; sometimes the waste was a mixture of all. So, in order to get some idea of the relative values and types of oil, I divided the waste into two classes, namely, fish guts and mixed waste.

In the boiling process, I found that I obtained oil of a lighter quality as to colour, freedom from strong smell and purity if the material was kept at 212° F. for one hour, keeping it well disintegrated by constant agitation during the whole period. By continuing the boiling, I found the oil became charred and got darker until it boiled itself at 361° F. I conducted some refining and bleaching tests but got only a few really satisfactory results owing to the constant varying of the oil origin, how-

ever careful I was. This, however, can eventually be entirely overcome by storage and blending when handled on a larger scale. I obtained the best results by the Fullers earth and sulphuric acid method.

Had I the apparatus, I should have much liked to have tried the cold extraction process and thus get a much finer oil which could probably be used for culinary purposes.

One of the principal problems associated with the manufacture of fish waste into economic products is its collection. In order that a report on this subject may be submitted, a port survey should be made; for it is obvious every district has its own peculiarities. Canneries, of course, could be easily grouped and a plant erected and operated co-operatively. In some cases, it might be economic to have a floating digester and dryer, leaving the subsequent making up of the feeds to a land factory.

Need for Protein Concentrates

As to the market for these feeds, I need hardly point out the increasing scarcity of protein concentrates in this country, and further, such feeds as do exist are controlled in foreign countries. It, therefore, only requires a series of demonstration experiments on a large scale at the different experimental farms to convince the farmer of the value of this new type of feed. I think there is little doubt that this standard concentrate can be put on the market at a less cost than linseed oil cake meal, the commonly used concentrate on the farm.

Process of Manufacture in Other Countries

The process of manufacture of these feeds as carried out in other countries is as follows: Fish waste in absolutely fresh condition alone must be taken, and, if the fish be large, they are cut up by machinery before being passed into the digester. There are many types of digesters, but I prefer those in which the temperature can be carefully controlled and in which disintegraters are employed. From this machine, part of the oil is extracted and the solid matter with a certain quantity of oil is then passed on to a press, where further oil is taken. The quantity of oil left must be governed by the feed you contemplate making subsequently. After the solid matter, now pressed, is emptied from the press, it is passed into a dryer. The type of dryer, if rotary, should be one in which there is no fear of the dust coming in contact with the fire, since it is very inflammable. From the dryer, the material is put either into storage for subsequent compounding during the winter months, or is passed through a mill and ground into a fine meal. If a vacuum dryer is used, great care must be taken to dry the material to the safety point.

The actual degree of dryness of each type of waste used will need careful chemical investigation, for it has been found that it has an important bearing on the digestibility of the protein, an important factor in marketing.

Once in the form of a meal, it is ready for compounding into the various feeds. These mixed compounds are then put into a horizontal mixer, steam jacketted, then passed into a pug mill. The face plate of the pug mill is cut so as to permit the dough to pass out in the form of spaghetti, only without a hollow core. This wormlike material passes on to a wire conveyer through a drying or baking oven. On emerging from the oven, the material is broken up to a size of $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in length. It is then ready for cooling and packing for transportation to the consumer.

I need hardly point out that much care and experience is necessary in the manufacture of these feeds, for we have to bear in mind that the material we are handling is chemically very delicate, and the slightest mistake in neglecting temperatures, compounding, drying, etc., spells failure in putting out a digestible food. From my own experience I can testify to vast quantities of apparently well-made fish feed products being put on the market with low digestibility and unpalatable to livestock.

There still remains much research to be done on the fish oils, which I am of an opinion can be made extremely valuable. There are many trades calling for good animal oils of this type that, so far as Canada is concerned, are compelled to import for want of manufacture in this country. Besides the necessity for a new source of good animal oil for domestic use, the drug, soap, paint, leather and other trades demand considerable quantities of oil of this nature.

From these remarks it will readily be realized that there is much further work to be done in connection with the fish waste problem: first, a careful survey as to the economic availability of raw material or fish waste; second, as to the most efficient type of plant, both on water and land, and its cost; third, the cost of manufacture of the various feeds and other products; fourth, the organization of the industry so as to save this waste and make some use of it; fifth, the fish fertilizer industry, being so closely allied to the feed industry, should be considered, making use of kelp and other marine products for the manufacture of 'complete fertilizers'.

APPROXIMATE COSTS

The following description of the plant required and statement of approximate costs in manufacturing fish waste into stock food and other useful products was obtained from Mr. J. B. Feilding on February 21, 1918. The figures relating to costs are approximate only and the Commission of Conservation does not hold itself responsible for their accuracy.

I. Plant

There are three distinct processes of manufacturing fish waste into fish meal, *viz.*, (a) the continuous, (b) the solvent, (c) the intermittent. The intermittent process does not destroy the food values of the material and is most suitable for the manufacture of feed in Canada, although it has never been used on the Atlantic coast.

Intermittent Process: The plant for manufacturing by the intermittent process consists of an engine, boiler and several digester units: Digesters can be had in any capacity from 2 to 6 tons each, but those with a capacity of 4½ tons are most economical.

The minimum-sized economic plant consists of 2 digester units and will treat 32 tons of fish waste in 24 hours. It can be erected anywhere in Canada, less duty and freight, for approximately $18,000 to $20,000. This does not include the cost of the building to house the plant, which would cost from $8,000 to $10,000 additional.

The same engine and boiler would carry an additional two units, each of which would cost from $4,000 to $5,000, f.o.b. point of shipment, but exclusive of the cost of installing and connecting.

Oil Refining Plant: For refining the oil produced, a filter press, an autoclave, a scourer, a cod-liver-oil outfit and a few sundries, are needed. Such a plant would cost $4,000 to $6,000, and it would cost $2,000 more to erect it.

Plant for Compounding Stock Food: All that is needed for this is a good mixer, bagger and weighing machine costing, say, $1,000 altogether.

Summary: The foregoing estimated costs may be summarized as follows:

Digester plant	$18,000	to	$20,000
Building for same	8,000	to	10,000
Oil-refining plant	4,000	to	6,000
Building for same	2,000	to	2,000
Compounding plant	1,000	to	1,000
Total estimated cost	$33,000	to	$39,000

II. Manufacturing Costs

Cost of operating a 2-unit plant for 12 hours:	
16 tons of fish waste at $2.00	$32.00
Labour: engineer at $7.00; 2 labourers at $2.50; and 1 boy at $1.00 a day	13.00
Coal: 4 tons at $10.00	40.00
Depreciation	5.00
Incidentals	5.00
Total cost of treating 16 tons	$95.00

The 16 tons of fish waste treated produces 6½ tons of fish meal (concentrate) which readily sold last year on the Buffalo market at $80.00 a ton, and 200 gals. of crude oil which also sold last year on the same market at 70 cents a gallon. The value of the products would thus be:

6½ tons of fish meal at $80.00	$520.00
200 gals. crude oil at 70 cents	140.00
	$660.00

In other words, for products which cost $95.00 to produce, $660.00 would be realized.

It must be remembered, however, that these products are perishable if left in their crude state, and their value varies from day to day according to their quality. The meal, therefore, has to be specially treated subsequently.

Meal for Cattle: The basis of this is the fish meal (concentrate) which may be assumed to have a protein content of 60 to 70 per cent. In fact, most of that made at Port Dover had a higher protein content than 60 per cent. The cattle meal, however, requires a protein content of only 40 per cent. and the fish meal, therefore, has to be diluted to bring the protein content down to this.

The ingredients added to the fish meal (concentrate)* constitute 50 per cent. of the finished feed. They cost about $2.25, the labour of mixing a ton costs $1.00, and bags $2.00.

The approximate nutritive value of this should be protein, 40 per cent; fat, 10 per cent.

Its present market price ranges from $65.00 to $70.00 a ton.

Hog Meal: Hog feed with about 75 per cent. fish meal (concentrate) as a basis, can be made at a cost of about $19.25 a ton. Its food value is: protein, 50 per cent; fat, 12 per cent; and its present market price is $90.00 a ton.

*During the experimental work at Port Dover, Mr. Feilding produced 2½ tons of cattle, hog and poultry feed. In addition to other ingredients, he used 125 lbs. feed flour, 1385 lbs. middlings, 140 lbs. bran, 1 bbl. salt, 5 bags hydrated lime and 1 bbl. molasses.

Feeding Tests with Fish Meals

By

J. H. GRISDALE, B. AGR.,

Director, Experimental Farms, Ottawa.

Fish meals for cattle and swine made at the experimental plant at Port Dover were sent to the Experimental Farm, at Ottawa, some months after the regular winter feeding experimental work had commenced. As nearly all available animals had been on some experimental feeds or treatment, they had thus acquired a lack of equality which prohibited the taking over of this experimental work and starting them immediately on fish meal, or on any other form of meal. For this reason, only a very limited number of animals could be selected to test the fish meals and the results of these tests were consequently of comparatively little value.

Five pure bred Ayrshire cows were selected for the testing of the dairy feed. These cows were all milking exceptionally well on the following rations: Clover hay, corn ensilage, mangels and meal composed of bran 4 parts, gluten 2 parts, dried distillers grains 2 parts, oil cake 1 part. The intention of this trial was to gradually accustom these animals to fish meal mixed with their regular meal ration and as soon as they acquired this taste, to replace gluten and oil cake with the fish meal for three weeks and then to revert to the original ration. The results were to be compiled from the last two weeks of each of the three periods of feeding. Although the cows were given a very small quantity of this fish meal each day for over two weeks, they persisted in refusing their grain altogether or picked out only the part which contained the least portion of this meal. Since these cows were both losing weight and decreasing in milk production, we finally cut them off this test. Undoubtedly, the cows could have been starved to a ration containing fish meal, but this was certainly not practicable.

The test of the fish meals for hogs was conducted under the same unfavourable circumstances as to animals available. However, two small lots of Berkshires were available for this work. One lot was fed the standard ration composed of shorts and corn, equal parts, plus 10 per cent. of fish meal; while the second lot had the same rations with an additional allowance of skim milk. Unfortunately, these two lots were not of exactly the same age, hence definite deductions could not be drawn.

However, the older pigs fed the fish meal without any skim milk, did fully as well as the younger pigs which were fed skim milk in addition to the fish meal and standard basic ration.

We have outlined for the summer experimental feeding a comparison of fish meal with digester tankage and skim milk in the feeding of newly-weaned pigs and we trust to have some figures of value before the completion of this trial.

However, may I draw your attention to the fact that the two lots of meal for swine given two different laboratory numbers appear to have been badly mixed in the shipping and, consequently, we will not know definitely whether it is the No. 10 or the No. 12 hog feed which is being given. There seems, however, not to be a great deal of difference in the analysis of these two meals and I trust such differences will not cause any marked variation or discrepancies in the test.

Commission of Conservation
CANADA

COMMITTEE ON FISHERIES, GAME AND FUR-BEARING ANIMALS

Utilization of Fish Waste in Canada

BY
J. B. FEILDING

OTTAWA—1918

Commission of Conservation

Constituted under "The Conservation Act," 8-9 Edward VII., chap. 27, 1909, and amending acts, 9-10 Edward VII, chap. 42, 1910, and 3-4 George V., chap. 12, 1913

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Commission of Conservation
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Utilization of Fish Waste in Canada

BY
J. B. FEILDING

OTTAWA—1918

Foreword

An investigation into the subject of the utilization of fish waste in Canada was undertaken for the Commission of Conservation by Mr. J. B. Feilding, who was authorized on October 2, 1916, to 'undertake work of an experimental character to determine the possibility of producing stock food and various valuable by-products from fish' caught in the Great lakes. It was at first proposed to conduct the experiments on Georgian bay, but, for various reasons, it was decided that Port Dover, on lake Erie, would be more suitable. The investigation covered a period of two months and was made at the latter place. The report which follows is Mr. Feilding's account of what was accomplished. The figures regarding cost of production appended to the report under the heading "Approximate Costs" were supplied at a later date by Mr. Feilding.

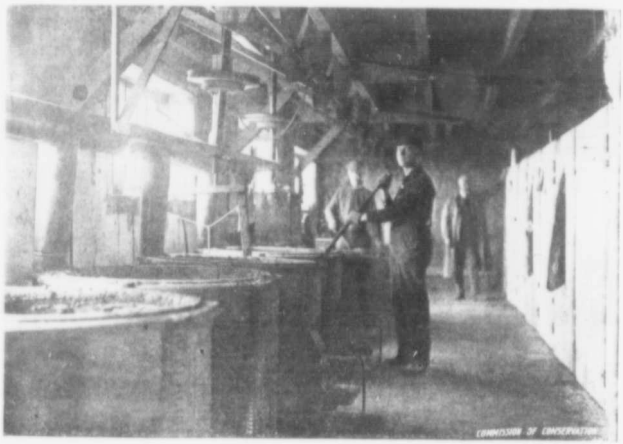
The Commission wishes to express its appreciation of the assistance rendered by, and courtesies received from, Hon. F. G. Macdiarmid, Minister of Public Works, Ontario, the late Mr. A. Sheriff, Deputy Minister of Game and Fisheries, Ontario, Mr. D. McDonald, Superintendent of Game and Fisheries, Ontario; from the following members of the staff of the Central Experimental Farm, Ottawa, Mr. J. H. Grisdale, Director, Dr. Frank T. Shutt, Assistant Director and Dominion Chemist; Mr. E. S. Archibald, Dominion Animal Husbandman and Mr. F. C. Elford, Dominion Poultry Husbandman. The Commission is also indebted to Prof. J. W. Bain, B.A. Sc., of Toronto University, for the use of his laboratory.

JAMES WHITE,

Assistant to Chairman, and Deputy Head

Ottawa, April 24, 1918.

Some of the Refuse from which Valuable Material was Secured, Port Dover, Ont.



Rendering Room where the Fish Waste was Treated to Separate the Valuable Oil Content, Port Dover, Ont.

Utilization of Fish Waste in Canada

By

J. B. Feilding

THE utilization of fish scrap in agriculture has been in vogue for centuries in many maritime countries. It is said that the Indians, before the advent of white men, used large quantities for fertilizing purposes in this country. While serving the British Government in the Malay States some twenty years ago, I found it the common practice to make use of fish, both as a fertilizer for the soil and a food for pigs, in many of the Chinese villages having access to large fishing areas. These practices had been handed down for generations. In the Shetland isles and west coast of Scotland, I have known surplus fish to be fed to both sheep and pigs. Doubtless, in these days, there is no surplus.

As for America, we hear of a fish-rendering factory being erected as far back as 1850 on Shelter island, New York, but, in all probability, the products manufactured were only oil and fertilizer; and, in fact, so far as this continent is concerned, fish scrap is converted only into fertilizer, except otherwise, perhaps, in a very small way.

It is in Germany we have to look for knowledge of the early using of fish waste as live-stock feed, and it was in that country, some eighteen years ago I studied the problem myself, though my work was entirely confined at that time to the manufacture of fish-waste products. Much useful investigation since that time has been done on the European continent and also in England.

In Germany, we find Lehmann stated in 1892, that fish meal ranks with meat meal and that laboratory results show that 98.6 per cent of the protein is digestible. Fink, in 1896, stated that he finished off steers on fish meal with other feeds, giving them 3 lbs. per day each, and as a result he obtained a gain of 303 lbs. in 90 days. Schenk, in 1903, conducted a very exhaustive series of experiments and, with other investigators, came to the conclusion that herbivorous live-stock were able to make better use of the protein in fish meal than they were of protein of vegetable origin. These investigators found fish meal universally an economic feed of very high value and that it left no taint with either milk, butter, bacon or eggs when fed in reasonable quantities on the farm. Martinelli, as reported in the Journal of the International Institute of Agriculture, states that animals fed on fish meal made more rapid gains than on meat meal, and not only that, but they were of superior quality.

The results of an interesting experiment conducted at the Agricultural College at Seal Hayne are reported in the Journal of the Board of Agriculture and Fisheries (England), 1914. In one of the experiments, it is pointed out that the substitution of fish meal for various other foods fed to pigs resulted in increased profits amounting in one series to 42 per cent, and in another to 94 per cent, notwithstanding the fact that the ration was higher in cost. In another experiment, fish meal was fed to cattle without any harmful results.

The rations of fish meal of North Sea origin as recommended by several authorities are: for cattle, 2 lbs. per 1,000 lbs. live weight; pigs, ½ lb. per 100 lbs. live weight; sheep, ¼ to ½ lb. per 200 lbs. live weight; while poultry can assimilate a ration containing 10 per cent fish meal.

From my own observations over a period of some twenty years, I can testify to its general use in Europe without harm to any of the usual live-stock on the farm. I have, personally, for many years used meals (compounded) for the raising of fish in fish-breeding establishments with the most satisfactory results.

By far the most important modern contribution to literature on the subject of the use of fish meal as a feed is contained in United States Agricultural Bulletin No. 378, the work of Mr. F. C. Weber, to whom we are greatly indebted. Mr. Weber appears to have collected abundant evidence as to the suitability and economic use of fish meal as a farm live-stock feed. He gives the following as the average analysis of some six meals used in his experiments:

	Per cent
Water	4.74
Ash	16.68
Total nitrogen	9.68
Protein	60.50
Fat	14.56
Crude fibre	0.61
Salt	5.78

In Mr. Weber's conclusion, he states that he is justified in saying that fish meal 'is a very effective supplement to a grain ration for pigs. . . . . In this experiment, fish meal was superior to tankage in all comparisons.' Dairy cows fed on a ration of fish meal compared with cows fed on a similar ration in which fish meal was replaced by cotton-seed meal, gave a greater yield of milk, but it contained a lower percentage of butter fat. However, the total amount of fat obtained was approximately the same in both cases.

Mr. I. W. Turrentine, of the United States Bureau of Soils, has, during the last few years, published the results of some interesting and

very valuable investigations relative to the utilization of fish waste as a fertilizer. In one Bulletin, No. 50, United States Department of Agriculture, he re-affirms what many other investigators of agricultural economy have stated, namely:

'It should be pointed out here that, with such fertilizing materials as dried blood, tankage, cotton-seed meal and fish scrap, it is better agricultural practice to feed these to stock . . . . . than to apply them direct to the soil. It can be taken as thoroughly well established that both the nitrogen and the phosphoric acid, after performing their rôle in the life processes of the adult animal, are eliminated. Then the high food value of these rich foods is utilized and at the same time the fertilizing elements are still available for use on the growing crops.'

Quantity of Fish Waste in Canada

With regard to the availability of fish waste in Canada, I am only in a position to offer an estimate, but, after conversing with many in the fishing industry, I feel sure I am not over-estimating when I place the quantity at something like 250,000 tons a year.

A few examples of waste may be useful as illustrating my assumption. It is stated authoritatively that it requires 88 lbs. of salmon on the Pacific coast to fill 48 one-pound cans; the balance, about 46 per cent, is waste. In the British Columbia salmon packing industry alone, it is estimated there is annually some 20,000 tons of waste. In the lobster packing industry, the percentage of waste is 75 per cent. In the Atlantic dry-fish curing industry, 45 per cent is waste. On the Great lakes, 44 per cent. of the total annual catch is waste.

Fishermen generally will inform one that, of the total catch of all species of fish caught at sea or on lake, 25 per cent consists of fish of no market value, and, further, of the remaining 75 per cent, an additional 25 per cent can be deducted as waste on gutting for market. In the halibut fishery, the head is the only waste brought ashore and it is estimated to be one-sixth of the weight of the 'cleaned' fish. It will be readily understood that, whatever the quantity of waste is, it is colossal.

The outstanding question, then, is how much of this waste is economically collectable and convertible. This is a factor for further investigation.

Obviously, the chief points of collection will be found on the two sea coasts.

Preparations for Experimenting

It was thought wise so late in the year (October) to commence investigations on the waste originating in the inland waters, where, it is

estimated, there is probably 8,000 to 10,000 tons of waste, an amount of material now being buried annually, or otherwise destroyed. With this in view, I got into communication with the Deputy Minister of Game and Fisheries for Ontario, who kindly offered me every facility.

Before commencing my work, I had to ascertain whether the facilities on Georgian bay or lake Erie would best be suited to my work. It was decided to open a small research station at Port Dover on lake Erie, in view of the fact that I had not only natural gas at my disposal, but also—the all important factor—a certainty of supply of such raw material as I required.

After selecting a site, I proceeded to ascertain what apparatus was available. In this I found great difficulty, for, on all sides, I was told nothing could be made or even adapted to my purpose for several weeks, and possibly months. I had, therefore, to content myself with four ordinary feed cookers which, of course, could only be operated at a maximum temperature of 212° F., so far as digesting was concerned.

For drying purposes I had to content myself with direct gas-fire heat without circulation, and for moulding, I had to use an Enterprise chopper. All other apparatus was on similar makeshift lines.

However, I had to make the best of the apparatus available and I am glad to say that I found it fairly capable of showing me approximately what was obtainable from the waste in a qualitative way.

On arrival at Port Dover, I had some difficulty in leasing suitable premises, but eventually secured part of an old tannery very much out of repair. In this, I erected what plant and machinery I could collect in the time and I subsequently engaged a man and boy to assist me in the work.

I then entered into an arrangement with the fishermen to supply me free of cost with such waste as I required, and, as a result, I took in for treatment and research about half a ton of raw material every other day.

Character of Feeds Manufactured

The waste I found very different from the material which I had had previous experience with in other countries, particularly on the North sea, and necessitated much more careful treatment than my make-shift apparatus permitted. However, with certain data in my possession, I proceeded to compound various live-stock feeds along the lines I had previously operated, some eighteen years ago, in Germany. These feeds were used experimentally at the Central Experimental Farm at Ottawa.* I fear I was unable, with the plant at my disposal, to extract

* See p. 14 for feeding experiments conducted at the Central Experimental Farm.

as much oil as I should have liked from the waste, which may result in the meal being too rich in fats, and further, such being the case, the feeds may change chemically through the generation of fatty acids, and thus become unpalatable. There is no doubt, however, that the material could, with suitable machinery, be made into exceedingly valuable feeding materials for the farm, if the raw material, namely, fish waste, can in every case, be obtained fresh.

In my opinion, this fish meal can be made at a cost that would admit of a fair profit to the manufacturer, assuming the waste were obtained free or at nominal cost.

From former experience, I have satisfied myself that fish meal, as such, being the dried residue with all freely-extracted oil withdrawn, must be compounded with 'mill offals' and other materials in order to prevent it chemically breaking down within reasonable time. The meal appears to be somewhat hygroscopic and, owing to its animal origin, it is easily influenced by climatic conditions.

The commodities manufactured must vary according to the type of waste used, and the purpose to which the finished product is to be put. No definite formulæ at this stage of the research can be stated as applicable to this fresh-water fish waste, until the keeping and feeding qualities have been tried out over an extended period.

There is no doubt, however, that satisfactory results can be eventually attained, but much more experience and further research must be applied, since this type of waste varies in composition almost every month of the year.

The types of feeds I compounded were:

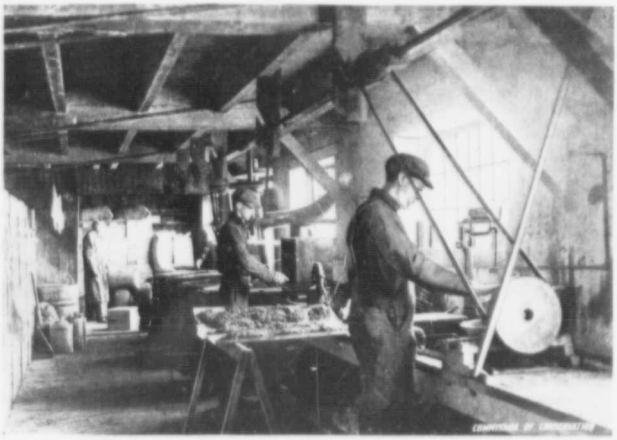
1. Cattle meal, 75 per cent fish meal.
2. Hog feed (cooked), 75 per cent fish meal.
3. Poultry scratch feed, 10 per cent fish meal.
4. Dog biscuit (baked), 25 per cent fish meal.

I am much indebted to Dr. Frank T. Shutt, the Dominion Chemist, for his chemical analyses of both raw material and other products of my work. The analyses forwarded by Dr. Shutt are as under:

FISH MEAL FEEDS

ANALYSIS OF PRODUCTS BY DR. FRANK T. SHUTT, DOMINION CHEMIST

Lab. No.	Ident. No.	Designation	Water	Protein	Fat	Carbo-hyd-rates	Fibre	Ash	Fertilizing constituents		
									Nitro-gen	Phosphoric acid	
										As phos. acid	As phos. of lime
28533	XS. ix P.D.	Fish Waste (viscera and content)	2.92	54.38	26.91	7.67	.81	7.31	8.70	3.06	6.68
28535	.....	Fish Meal (whole fish)	2.10	61.88	20.34	2.98	.70	12.00	9.90	4.82	10.53
28534	No. 10	Hog feed concentrate	1.88	49.07	15.70	11.77	3.44	18.14	7.85	4.53	9.90
28537	No. 13	Poultry scratch food	5.81	25.55	8.95	43.95	6.96	8.78	4.09	2.31	5.05
28538	No. 12	Cattle feed concentrate	12.20	39.13	11.00	19.39	3.17	15.11	6.26	4.00	8.74
28673	No. 12 P.D.	Hog feed concentrate	3.99	53.54	17.33	11.32	1.84	11.98	8.57	4.23	9.24
28674	No. 15	Poultry scratch food	2.66	17.86	4.20	58.82	9.72	6.74	2.86	2.19	4.78



Grinding and Compounding Fish Waste Products, Port Dover, Ont.

Laboratory, Port Dover, Ont.

I estimate the market values of these feeds, in normal times, to be as follows: the cattle feed, $40 per ton; hog feed, $50 per ton; poultry feed, $45 per ton and the dog biscuit, $100 per ton.

For comparison it may be of interest to quote recent prices (April, 1917) given me by some leading manufacturers and dealers of other protein concentrates now used by farmers in this country:

	Protein	*Price*	
Linseed cake meal	40 per cent	$54	f.o.b., Toronto
Cotton cake meal	20 to 24 per cent	$40	" "
Tankage	60 per cent	$65	" "

Besides the experimental feeding being conducted by the Central Experimental Farm, I, myself, tried a ton on my own farm. Being absent from home on this investigation, I could not conduct the experiment on the usual lines, but, in any case, my chief object was to ascertain if this fresh-water fish waste was as attractive to live-stock as salt-water waste of which I have had previous experience. As a result, I have no hesitation in saying that all stock fed on this material properly compounded did well and relished it. I fed it to 20 head of cattle, 20 head of pigs and about 100 poultry. Further, I fattened off one 'beast' on fish meal and bran and sold him at 8½ cents per pound on the hoof.

I am, therefore, satisfied that fresh-water fish waste properly made up is a suitable and economic protein and fat concentrate for all farm live-stock.

Oil

So much for the utilization of the dry residue of fish waste. The other economic product obtained is oil. This I found varied both in quantity and quality in relation to the type of waste brought into port.

Some days the waste would consist chiefly of lake herring viscera, while on others, of whole fish, chiefly eel pouts (*lota maculosa*) and small blue pickerel (*stizostedion canadense*) that had been 'bridled'; sometimes the waste was a mixture of all. So, in order to get some idea of the relative values and types of oil, I divided the waste into two classes, namely, fish guts and mixed waste.

In the boiling process, I found that I obtained oil of a lighter quality as to colour, freedom from strong smell and purity if the material was kept at 212° F. for one hour, keeping it well disintegrated by constant agitation during the whole period. By continuing the boiling, I found the oil became charred and got darker until it boiled itself at 361° F. I conducted some refining and bleaching tests but got only a few really satisfactory results owing to the constant varying of the oil origin, how-

ever careful I was. This, however, can eventually be entirely overcome by storage and blending when handled on a larger scale. I obtained the best results by the Fullers earth and sulphuric acid method.

Had I the apparatus, I should have much liked to have tried the cold extraction process and thus get a much finer oil which could probably be used for culinary purposes.

One of the principal problems associated with the manufacture of fish waste into economic products is its collection. In order that a report on this subject may be submitted, a port survey should be made; for it is obvious every district has its own peculiarities. Canneries, of course, could be easily grouped and a plant erected and operated co-operatively. In some cases, it might be economic to have a floating digester and dryer, leaving the subsequent making up of the feeds to a land factory.

Need for Protein Concentrates

As to the market for these feeds, I need hardly point out the increasing scarcity of protein concentrates in this country, and further, such feeds as do exist are controlled in foreign countries. It, therefore, only requires a series of demonstration experiments on a large scale at the different experimental farms to convince the farmer of the value of this new type of feed. I think there is little doubt that this standard concentrate can be put on the market at a less cost than linseed oil cake meal, the commonly used concentrate on the farm.

Process of Manufacture in Other Countries

The process of manufacture of these feeds as carried out in other countries is as follows: Fish waste in absolutely fresh condition alone must be taken, and, if the fish be large, they are cut up by machinery before being passed into the digester. There are many types of digesters, but I prefer those in which the temperature can be carefully controlled and in which disintegraters are employed. From this machine, part of the oil is extracted and the solid matter with a certain quantity of oil is then passed on to a press, where further oil is taken. The quantity of oil left must be governed by the feed you contemplate making subsequently. After the solid matter, now pressed, is emptied from the press, it is passed into a dryer. The type of dryer, if rotary, should be one in which there is no fear of the dust coming in contact with the fire, since it is very inflammable. From the dryer, the material is put either into storage for subsequent compounding during the winter months, or is passed through a mill and ground into a fine meal. If a vacuum dryer is used, great care must be taken to dry the material to the safety point.

The actual degree of dryness of each type of waste used will need careful chemical investigation, for it has been found that it has an important bearing on the digestibility of the protein, an important factor in marketing.

Once in the form of a meal, it is ready for compounding into the various feeds. These mixed compounds are then put into a horizontal mixer, steam jacketted, then passed into a pug mill. The face plate of the pug mill is cut so as to permit the dough to pass out in the form of spaghetti, only without a hollow core. This wormlike material passes on to a wire conveyer through a drying or baking oven. On emerging from the oven, the material is broken up to a size of $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in length. It is then ready for cooling and packing for transportation to the consumer.

I need hardly point out that much care and experience is necessary in the manufacture of these feeds, for we have to bear in mind that the material we are handling is chemically very delicate, and the slightest mistake in neglecting temperatures, compounding, drying, etc., spells failure in putting out a digestible food. From my own experience I can testify to vast quantities of apparently well-made fish feed products being put on the market with low digestibility and unpalatable to livestock.

There still remains much research to be done on the fish oils, which I am of an opinion can be made extremely valuable. There are many trades calling for good animal oils of this type that, so far as Canada is concerned, are compelled to import for want of manufacture in this country. Besides the necessity for a new source of good animal oil for domestic use, the drug, soap, paint, leather and other trades demand considerable quantities of oil of this nature.

From these remarks it will readily be realized that there is much further work to be done in connection with the fish waste problem: first, a careful survey as to the economic availability of raw material or fish waste; second, as to the most efficient type of plant, both on water and land, and its cost; third, the cost of manufacture of the various feeds and other products; fourth, the organization of the industry so as to save this waste and make some use of it; fifth, the fish fertilizer industry, being so closely allied to the feed industry, should be considered, making use of kelp and other marine products for the manufacture of 'complete fertilizers'.

APPROXIMATE COSTS

The following description of the plant required and statement of approximate costs in manufacturing fish waste into stock food and other useful products was obtained from Mr. J. B. Feilding on February 21, 1918. The figures relating to costs are approximate only and the Commission of Conservation does not hold itself responsible for their accuracy.

I. Plant

There are three distinct processes of manufacturing fish waste into fish meal, *viz.*, (a) the continuous, (b) the solvent, (c) the intermittent. The intermittent process does not destroy the food values of the material and is most suitable for the manufacture of feed in Canada, although it has never been used on the Atlantic coast.

Intermittent Process: The plant for manufacturing by the intermittent process consists of an engine, boiler and several digester units: Digesters can be had in any capacity from 2 to 6 tons each, but those with a capacity of 4½ tons are most economical.

The minimum-sized economic plant consists of 2 digester units and will treat 32 tons of fish waste in 24 hours. It can be erected anywhere in Canada, less duty and freight, for approximately $18,000 to $20,000. This does not include the cost of the building to house the plant, which would cost from $8,000 to $10,000 additional.

The same engine and boiler would carry an additional two units, each of which would cost from $4,000 to $5,000, f.o.b. point of shipment, but exclusive of the cost of installing and connecting.

Oil Refining Plant: For refining the oil produced, a filter press, an autoclave, a scourer, a cod-liver-oil outfit and a few sundries, are needed. Such a plant would cost $4,000 to $6,000, and it would cost $2,000 more to erect it.

Plant for Compounding Stock Food: All that is needed for this is a good mixer, bagger and weighing machine costing, say, $1,000 altogether.

Summary: The foregoing estimated costs may be summarized as follows:

Digester plant	$18,000	to	$20,000
Building for same	8,000	to	10,000
Oil-refining plant	4,000	to	6,000
Building for same	2,000	to	2,000
Compounding plant	1,000	to	1,000
Total estimated cost	$33,000	to	$39,000

II. Manufacturing Costs

Cost of operating a 2-unit plant for 12 hours:	
16 tons of fish waste at $2.00	$32.00
Labour: engineer at $7.00; 2 labourers at $2.50; and 1 boy at $1.00 a day	13.00
Coal: 4 tons at $10.00	40.00
Depreciation	5.00
Incidentals	5.00
Total cost of treating 16 tons	$95.00

The 16 tons of fish waste treated produces 6½ tons of fish meal (concentrate) which readily sold last year on the Buffalo market at $80.00 a ton, and 200 gals. of crude oil which also sold last year on the same market at 70 cents a gallon. The value of the products would thus be:

6½ tons of fish meal at $80.00	$520.00
200 gals. crude oil at 70 cents	140.00
	$660.00

In other words, for products which cost $95.00 to produce, $660.00 would be realized.

It must be remembered, however, that these products are perishable if left in their crude state, and their value varies from day to day according to their quality. The meal, therefore, has to be specially treated subsequently.

Meal for Cattle: The basis of this is the fish meal (concentrate) which may be assumed to have a protein content of 60 to 70 per cent. In fact, most of that made at Port Dover had a higher protein content than 60 per cent. The cattle meal, however, requires a protein content of only 40 per cent. and the fish meal, therefore, has to be diluted to bring the protein content down to this.

The ingredients added to the fish meal (concentrate)* constitute 50 per cent. of the finished feed. They cost about $2.25, the labour of mixing a ton costs $1.00, and bags $2.00.

The approximate nutritive value of this should be protein, 40 per cent; fat, 10 per cent.

Its present market price ranges from $65.00 to $70.00 a ton.

Hog Meal: Hog feed with about 75 per cent. fish meal (concentrate) as a basis, can be made at a cost of about $19.25 a ton. Its food value is: protein, 50 per cent; fat, 12 per cent; and its present market price is $90.00 a ton.

*During the experimental work at Port Dover, Mr. Feilding produced 2½ tons of cattle, hog and poultry feed. In addition to other ingredients, he used 125 lbs. feed flour, 1385 lbs. middlings, 140 lbs. bran, 1 bbl. salt, 5 bags hydrated lime and 1 bbl. molasses.

Feeding Tests with Fish Meals

By

J. H. GRISDALE, B. AGR.,

Director, Experimental Farms, Ottawa.

Fish meals for cattle and swine made at the experimental plant at Port Dover were sent to the Experimental Farm, at Ottawa, some months after the regular winter feeding experimental work had commenced. As nearly all available animals had been on some experimental feeds or treatment, they had thus acquired a lack of equality which prohibited the taking over of this experimental work and starting them immediately on fish meal, or on any other form of meal. For this reason, only a very limited number of animals could be selected to test the fish meals and the results of these tests were consequently of comparatively little value.

Five pure bred Ayrshire cows were selected for the testing of the dairy feed. These cows were all milking exceptionally well on the following rations: Clover hay, corn ensilage, mangels and meal composed of bran 4 parts, gluten 2 parts, dried distillers grains 2 parts, oil cake 1 part. The intention of this trial was to gradually accustom these animals to fish meal mixed with their regular meal ration and as soon as they acquired this taste, to replace gluten and oil cake with the fish meal for three weeks and then to revert to the original ration. The results were to be compiled from the last two weeks of each of the three periods of feeding. Although the cows were given a very small quantity of this fish meal each day for over two weeks, they persisted in refusing their grain altogether or picked out only the part which contained the least portion of this meal. Since these cows were both losing weight and decreasing in milk production, we finally cut them off this test. Undoubtedly, the cows could have been starved to a ration containing fish meal, but this was certainly not practicable.

The test of the fish meals for hogs was conducted under the same unfavourable circumstances as to animals available. However, two small lots of Berkshires were available for this work. One lot was fed the standard ration composed of shorts and corn, equal parts, plus 10 per cent. of fish meal; while the second lot had the same rations with an additional allowance of skim milk. Unfortunately, these two lots were not of exactly the same age, hence definite deductions could not be drawn.

However, the older pigs fed the fish meal without any skim milk, did fully as well as the younger pigs which were fed skim milk in addition to the fish meal and standard basic ration.

We have outlined for the summer experimental feeding a comparison of fish meal with digester tankage and skim milk in the feeding of newly-weaned pigs and we trust to have some figures of value before the completion of this trial.

However, may I draw your attention to the fact that the two lots of meal for swine given two different laboratory numbers appear to have been badly mixed in the shipping and, consequently, we will not know definitely whether it is the No. 10 or the No. 12 hog feed which is being given. There seems, however, not to be a great deal of difference in the analysis of these two meals and I trust such differences will not cause any marked variation or discrepancies in the test.