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INTRODUCTION

The method used by many commercial firms to obtain the oil from cod-livers is to steam the raw livers for some definite period. The steaming breaks the oil cells of the livers. Then the cooked livers, the chum, is allowed to stand for a definite period so that some of the oil can rise to the surface of the chum. This oil is skimmed from the cooker and is No. 1 grade or Medicinal Oil. The chum still contains a large percentage of oil which can only be separated by some mechanical means. The ordinary way is to put the chum into canvas bags and to press the oil from the chum. This oil is a lower grade oil and not used for human consumption.

In the Fishing Gazette, May 1929, Eric Loffler, Fisheries Engineer U. S. Bureau of Fisheries, reports in an article "More and Better Liver Oils" that by the use of a centrifugal extractor only ½% of the original oil is left in the chum. A comparison of this method with that of pressing the chum can be shown more clearly by quoting from this article: "Within the plants, the livers are cooked for varying periods in live steam with a resultant extraction of about one-half the oil. If the livers are good this first extraction is medicinal oil for nutritive uses. The liver residue is packed in canvas bags then put through a heavy screw press with a further extraction of 15%-18%, ordinarily suitable for tanning purposes. The remainder or "chum" still containing about 25% of the original oil goes to the dryer to be made into liver meal.

To the liver oil industry has been introduced the centrifugal extractor which has proven so efficient in other lines.

As before, the first extraction is accomplished by the use of live steam. From the steam boilers the livers travel automatically to the new extractors to be whirled at a very high speed until the remaining oil is separated from the liver residue. Then remains only about 4% of the original oil in the chum. Thus with less labour and in a shorter period a saving of 24% of the oil is accomplished."

During the Summer of 1929 the writer began investigating the use of centrifugal extractors to recover the oil in cod livers. At this time the only centrifuge that was available was a 5 "perforated basket" hand driven type of machine. This machine is not suited for this type of work as the oil has to pass through the chum before it can be collected. The chum plugs the perforations very rapidly thus preventing the oil from leaving the basket. The basket could only hold 150 to 200 grams of chum and the speed was about 3,000 R. P. M. The oil content of the livers with this extractor was reduced to about 16% of the original oil in the raw material.

This report covers the work that has been carried out by the writer using centrifuges that have a solid wall bowl and similar to those used by Loffler in his investigation of this problem.

EQUIPMENT USED

A cylindrical cooker, of the type used in the oil industry made of galvanized iron was used to cook the raw material. At the apex of the cone there was a valve to drain the water from the cooked material. The capacity of the cooker was about 50 pounds.

An autoclave was used as a steam boiler to provide the steam to cook the livers. It was very difficult with this equipment to keep the steam pressure at 15 pounds per square inch during the period of cooking. The steam was introduced into the cooker by a pipe extending down the axis of the cylinder; the end of the pipe was about two inches above the apex of the conical bottom. All the pipe lines for the steam were 1/8 inch brass tubing.

Two types of centrifuges were used. These are described later in the report.

METHOD OF PROCESSING THE RAW LIVERS

Washing the Raw Material.

The raw material is washed carefully with fresh water to remove all foreign substances. During the washing all gall bladders and other foreign tissues and organs attached to the liver are removed.

SAMPLING OF LIVERS FOR OIL ANALYSIS

The oil content of each lot of livers is determined by taking an ether extract of a sample of the raw material in a Soxhlet Extractor. To obtain the sample every fifth liver is taken when the raw material is being washed. Each lot of five livers being about the same size. The sample lots are ground up in a meat chopper. The ground up livers are thoroughly mixed and the sample taken for the analysis.

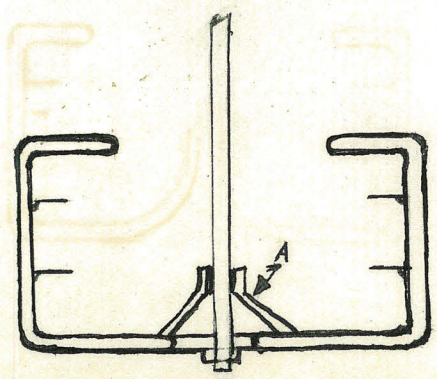
METHOD OF COOKING

The washed livers are cooked with live steam in the cooker which has already been described. The steam pressure in the boiler is kept at 15 pounds per square inch during the time of cooking. The livers are cooked for half an hour. The process takes place in two stages, the first fifteen minutes the steam is turned on so that the livers bubble vigorously, for the last fifteen minutes the steam is cut down so that the bubbling in the cooker is very moderate. This prevents the chance that the oil and water will form an emulsion. After cooking is completed the cooked livers are allowed to stand for 15 minutes so that the oil that has been liberated from the ruptured cells can separate out to the top of the cooker. This oil is skimmed off, filtered through cotton and weighed. This is the skimmed oil. After the oil has been skimmed from the cooker the water is drained off the cooked material and the remaining solid, "chum", which still contains oil is run into one of the centrifuges to recover whatever oil is obtainable by this method.

DESCRIPTION AND USE OF THE CENTRIFUGAL EXTRACTORS

The two extractors were obtained by the Experimental Station through the courtesy of the Tolhurst Machine Works, Troy, New York, and the Fletcher Works, Philadelphia. These machines are similar to the ones used by Leffler.

The Tolhurst machine is a suspended bowl laboratory type machine. The diameter of the bowl is 12". It runs at 1725 R.P.M. The bowl is solid wall type which cannot be detached from the shaft of the motor.



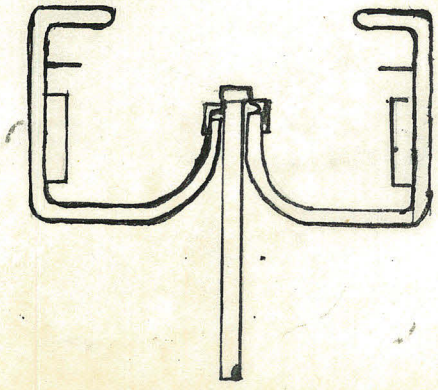
The sketch shows a cross section of the bowl. The hot chum from the cooker is fed into the spinning bowl. It is packed against the side under the lower flange. As the oil is lighter than the chum and water it is in the layer next the centre of the bowl. When more chum is added the oil is forced up into the next section through openings in the flanges. When the bowl is filled with oil, chum and water, the oil flows over the rim of the bowl into an outer casing which is drained by a spout. It can be easily noted when most of the oil is out of the bowl as the oil layer and the water chum layer are different in colour. Usually when the bowl is stopped some of the oil remains behind; this has been a thin layer next the solid. To recover this oil a little water is run into the bowl when it is spinning to force this oil over the rim of the bowl. Care has to be taken not to add enough water so that solid matter is also forced over the edge of the bowl.

This type of machine is a batch machine. When the bowl is filled it must be stopped in order to empty it. The solids are emptied through an opening by raising the cone A and scraping them from the bowl. It is not possible to clean all the solids from the bowl so for this reason the chum could not be collected and weighed. It is very difficult to clean this machine quickly unless steam or hot water is turned into the bowl and the solids are flushed out. This would not be suitable in the oil industry as the chum is collected in many plants to be used for liver meal.

Each batch of chum was centrifuged until no oil dripped from the spout, then a little water was added to recover the thin layer of oil which always remained behind. The time of operation for centrifuging each batch is about twenty minutes. The oil that is collected is filtered through cotton, allowed to stand so that any water can separate out and weighed, so that the yield of oil obtained can be calculated.

THE FLETCHER MACHINE

This centrifuge has a 12" solid wall bowl which runs at 2200 R. P. M. The bowl rests on a shaft which is driven by a motor by means of a belt.



The sketch shows the cross section of the bowl.

A feature of this type of machine is the method of collecting the oil. Two adjustable spouts are placed so that the ends of these extend under the rim of the bowl. These are adjusted by a screw mechanism ~~so that~~ they can be moved in and out. By this means the oil that collects above the flange can be taken off through a spout in a manner that resembles the separation of cream by a cream separator. This has the advantage that water does not have to be added to the bowl to collect the last trace of oil. Also, the bowl does not have to be completely filled before the oil can be collected.

The hot chum from the cooker is run into the spinning bowl, and when sufficient oil has collected above the upper flange it is drawn off by the spouts. This oil is filtered through cotton to remove any solids. The machine is run loaded with the chum until no more oil can be collected by the spouts. This machine is a batch type but the bowl can be taken from the spindle, emptied and cleaned very easily.

As in the other case the oil that is collected from the centrifuge is allowed to stand so that any water can separate from it. It is then weighed so that the yield can be calculated.

EXPERIMENTAL WORK

Due to the scarcity of the supply of livers in the vicinity of the Station during the summer of 1930, only a very few runs were able to be obtained. Before any definite conclusions can be made from a set of results obtained from this type of work, a great many observations are necessary due to the changing conditions of the material which varies with the physiological condition of the fish at the time when it is caught. From the few results that have been obtained on this work it can be seen that none of the yields that are obtained are as large as those reported by Leffler.

A set of results is given to illustrate the method of calculating the yield of cod-liver oil.

Machine: Tolhurst

Livers: Fresh

Weight of raw material.....30.0 lbs.
% oil in the raw livers 58.8%
Weight of oil in the raw livers .....17.6 lbs.

Yield of oil.

	Weight of oil	% of weight of raw livers	% of original oil
Skimmed	5.0 lbs.	16.6	28.4
Centrifuged	6.0 "	20.0	34.1
Total	11.0	36.0	62.5

RESULTS OBTAINED WITH THE TOLHURST MACHINE

The yield of oil is calculated on the basis of the percentage of the weight of the raw livers processed.

Lot No.	Wt. of raw livers	Yield of Oil		
		Skimmed	Centrifuged	Total
1 +	30.0 lbs.	21.7%	25.0%	46.7%
2	30.0	16.6	20.0	36.6
3	21.0	20.2	14.3	34.5
4	17.9	27.3	11.9	39.2
5	20.4	26.5	15.3	41.8

The following table of results gives the yield of oil calculated as the percentage of the original oil recovered.

Lot. No.	Wt. of raw livers	% oil in the raw livers	Yield		
			Skimmed	Centrifuged	Total.
1 +	30.0 lbs.	58.3%	37.3%	43.2%	80.5%
2	30.0	58.8	28.4	34.1	62.5
3	21.0	57.5	35.3	25.2	60.5
4	17.9	67.7	40.3	17.9	58.2
5	20.4	66.0	39.8	23.7	63.5

+ The livers that were used in Lot No. 1 were frozen. The yield is about 20% greater than any of the other results. This would be expected from the results that have been obtained on the yield of oil from frozen livers at this Station.

RESULTS OBTAINED WITH THE FLETCHER MACHINE

Weight of raw livers	18.6 lbs.
% oil in the raw livers	64.0%
Weight of oil in the raw livers	11.9 lbs.

Yield of oil.	Wt. in lbs.	% of wt. of raw livers	% of the original oil
Skimmed	5.75 lbs.	30.9%	48.3
Centrifuged	2.75	14.8	23.2
Total	8.50	45.7	71.5

Weight of Chum	9.0 lbs.
% of oil in chum	26.4%
Wt. of oil in chum	2.4 lbs.

Theoretical yield of oil 11.9 lbs. - 2.4 lbs. = 9.5 lbs.
Weight of oil lost in process 9.5 " - 8.5 " = 1.0 "

% of the original recovered $\frac{8.5 \times 100}{11.9} = 71.5\%$

% of the original oil in the chum $\frac{2.4 \times 100}{11.9} = 20.1\%$

% of the original oil lost $\frac{1.0 \times 100}{11.9} = 8.4\%$

CONCLUSION

So far it has not been possible to develop a method to recover the oil from cod-livers by the use of centrifugal extractors which give a yield of oil approaching 95% of the original oil in the raw livers.

The length of time of cooking the livers and the steam pressure used may not be the optimum conditions to produce the highest yield of oil. If further investigation is carried out on this problem it is suggested that these factors be varied over a wide range to find the best conditions for the processing of the raw livers.