TECHNICAL NOTE NO. 14--A BRIEF STUDY OF THE ALKALI PROCESS FOR RECOVERY OF OIL FROM PINK SALMON CANNERY WASTE

ABSTRACT

THE EFFECTS OF VARYING THE TIME OF DIGESTION OF A FEW SAMPLES OF PINK-SALMON CANNERY WASTE AT CERTAIN TEMPERATURES AND ALKALI (SODIUM HYDROXIDE) CONCENTRATIONS WERE STUDIED. AT 200° F. AND WITH 1.5 PARTS OF SODIUM HYDROXIDE PER 100 PARTS OF WASTE, THE MAXIMUM RECOVERY OF OIL WAS OBTAINED BY DIGESTING ABOUT 35 TO 40 MINUTES. AT 180° F. WITH THE SAME AMOUNT OF ALKALI, THE DIGESTION WAS VERY SLOW AND NO TIME FOR MAXIMUM RECOVERY WAS DETERMINED. AT 240° F. AND THE SAME ALKALI CONCENTRATION, THE DIGESTION WAS DIFFICULT TO CONTROL; TIME FOR MAXIMUM RECOVERY AT THAT TEMPERATURE APPEARED TO BE ABOUT 20 MINUTES. AT 200° F. WITH 3.0 PARTS OF SODIUM HYDROXIDE PER 100 PARTS OF WASTE, MAXIMUM RECOVERY WAS ATTAINED BY DIGESTING ONLY 15 TO 20 MINUTES, BUT THE FORMATION OF EMULSION WAS EXCESSIVE. IN EVERY CASE THE RATES OF CHANGE IN OIL RECOVERY ON BOTH SIDES OF THE OPTIMUM TIME WERE SMALL; THAT IS, THE OPTIMA TIMES WERE NOT CRITICAL.

INTRODUCTION

The potential value of the oil in salmon cannery trimmings has been more or less appreciated for many years. However, the bulk of this raw material is still being wasted, because data on possible reduction methods have been insufficient to assure cannery operators of profits commensurate with the investment. A process which might prove sufficiently profitable is the digestion of the trimmings with an alkali and the separation of the oil with a centrifuge. Such a process has proved highly successful for the recovery of vitamin oils from fish livers and viscera. Anderson (1945) recommended an alkali digestion process for the recovery of oil from the head-collar portion of salmon cannery waste. Butler and Miyauchi (1947) adapted Anderson's method to pilot-plant-scale digestions of several types of salmon cannery waste. Carlson and Magnusson (1948), using frozen pink-salmon waste only, made a preliminary study of the effects on oil recovery of particle size, time, temperature, and alkali concentration. They concluded that the waste should be ground or shredded but that extreme disintegration was unnecessary. Although they found that digestion at 200° F. for about 50 minutes with 1.5 parts of sodium hydroxide to 100 parts of waste was fairly satisfactory, they recognized the need for more experimental data on each of the variables.

In order to secure additional data on the effect of varying the digestion conditions, seven series of four (in one case three) trials each were performed and at near conditions previously found quite satisfactory. The only variable for the four trials within each series was the time of digestion. Three series of digestions were carried out at 200° F. with 1.5 parts of sodium hydroxide per 100 parts of waste; in two series at the same temperature 3.0 parts of alkali per 100 parts of waste were used; in one series at 180° F. and in another at 240° F., 1.5 parts of alkali per 100 parts of waste were employed.

The advantages of using a single lot of raw material for all the series were recognized; however the limitations of physical equipment and personnel permitted only one series of four trials on each operating day. As spoilage in unfrozen waste is rapid and as freezing the waste would be commercially imprac-

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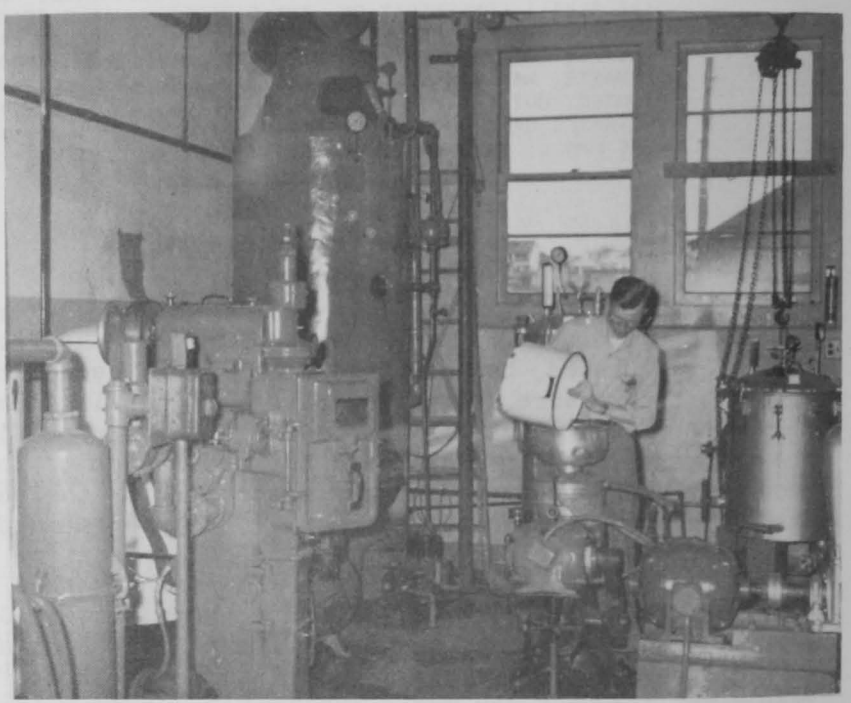
tical, new well-mixed lots of fresh waste were used for each series of four digestions. Therefore, the oil recovery data of a trial in one series cannot be compared directly with the data of a trial in another series. The present study is primarily a study of the effect of varying the digestion time under four sets of temperature and alkali conditions.

PROCEDURE AND EQUIPMENT

Whole pink-salmon cannery waste was secured at a Ketchikan cannery, which handled only trap-caught fish. Representative lots of waste were collected in wire baskets directly from the end of the flumes coming from the butchering and cleaning operations. After the waste was well drained, it was taken immediately to the laboratory and put through a meat-bone chopper (hogger). The final hogged mass consisted of pieces not over one-half inch in narrowest width. The entire lot of ground material was mixed and then divided equally into four sublots of approximately 100 pounds apiece. At the same time a moderate sized representative sample was removed. This sample was reground in a laboratory meat grinder, and the well macerated mass was quartered to obtain the proper size sample for analysis. The oil content of the sample was determined by extraction with acetone in a Baily-Walker apparatus and purification of the extract in ethyl ether in accordance with the method of Stansby and Lemon (1937), as modified by Voth (1946).



PILOT PLANT EQUIPMENT USED FOR PINK SALMON WASTE STUDY AT KETCHIKAN FISHERY PRODUCTS LABORATORY. SHOWN ARE STEAM BOILER, CENTRIFUGE, AND RETORT.

The digestions were carried out in the equipment described by Carlson and Magnusson (1948). This consisted of an upright 58-gallon retort fitted with steam inlets near the bottom and power-driven stirring propellors; it was equipped with an adjustable level draining-skimming device. Skimming the digestion liquors from the top was desirable, because when they were drained out at the bottom the oil layer was held back by the undigested bones. For digestion at 180° and 200° F., a sheet aluminum lid was placed on the retort. The temperatures were noted with an all-metal dial-type thermometer having a 24-inch stem. For digestions at 240° F., a regular pressure retort cover (clamped down with turnbuckles and equipped with a thermometer and a pressure gauge) was used.

In preliminary tests it was found that whenever the digestion had been started with cold water there was excessive bumping. Therefore, before each trial the necessary water was heated to about 180° F. by injecting steam. The amount of hot water was adjusted to 12 gallons (100 lbs.), the stirrer was start-

ed and the sodium hydroxide was added. As soon as the alkali had dissolved, the weighted waste (about 100 lbs.) was added and the steam flow was adjusted so that the desired final temperature was reached in 10 minutes. At the end of the chosen processing period the steam was turned off and the stirrer stopped, and the digested mixture was allowed to settle for 15 minutes. In the trials at 240° F. it required most of the settling period to release the pressure; when the pressure was released more rapidly the digestion mixture boiled and foamed over and much of the oil layer was lost.

After the settling period, the oil-rich top layer was skimmed off and passed through a centrifugal oil purifier which had been preheated with boiling water. Then most of the remaining supernatent liquors were also passed through the centrifuge. To eliminate possible trouble from undigested bones or flesh in the centrifuge, the liquors were passed through a 12-mesh-per-inch sieve before centrifuging. The purifier readily separated the oil, which was clear and amber colored. The odor of the oil, reminiscent of fried fresh salmon, indicated slight scorching. The oil purifier normally retained a moderate quantity of liquor, including some oil, at the end of each operation. These "held back" liquors were further separated in a small laboratory centrifuge. All the recovered oil from each trial was combined and weighed to determine the oil yield. The vitamin A content of each sample was determined spectrophotometrically on the isopropanol solution of the whole oil.

RESULTS AND DISCUSSIONS

Table 1 presents the oil recovery data for the seven series of digestions. The first series at 200° F. with 1.5 parts sodium hydroxide per 100 parts of waste indicated that the optimum digestion time (including the 10 minutes to reach the digestion temperature but not including the 15 minutes settling time) for maximum recovery of oil was probably less than 40 minutes. The second series under these conditions indicated that the optimum digestion time was probably a little more than 35 minutes. The third series indicated that the proper time was close to 36 minutes. Thus the three series checked each other well, all indicating that the probable optimum digestion time was within the range of 35 to 40 minutes. These digestions at 200° F. with 1.5 parts alkali were easy to control; there was no foaming and there was only an insignificant emulsion layer between the oil and water layers.

In the two series at 200° F. with 3.0 parts of sodium hydroxide per 100 parts of waste there was considerable emulsification, and at digestion times over 20 minutes there were excessive amounts of foam. Both series indicated that the optimum digestion time for maximum oil recovery was between 15 and 20 minutes.

At 180° F. with 1.5 parts alkali, the digestion was slow. No advantage to digestion at this low temperature was observed. No optimum digestion time was indicated by the data.

At 240° F. it was impossible to lower the pressure rapidly, and therefore the digestion probably continued at a significant rate during the settling period. Digestion of pink salmon waste with 1.5 percent sodium hydroxide at 240° F. yielded a thick emulsion which was difficult to centrifuge. The optimum processing time (not including the settling period) for this temperature appeared to be around 20 minutes.

The spectrophotometric data indicated only moderate amounts of vitamin A in the raw materials used, averaging less than 1,000 U.S.P. units per gram of oil. On the basis of the spectrophotometric data on the raw oils and the

Effect of Varying Time, Temperature, and Alkali Concentration on Recovery of Oil in Alkali Digestion of Pink-Salmon Waste

Amount of Sodium Hydroxide Added Per 100 lbs. of Waste	Digestion Temperature	Oil Content of Raw Material Per 100 lbs. of Waste	Digestion Time[1]	Oil Recovered Per 100 lbs. of Waste	Efficiency of Oil Recovery[2]
Lb.	Degrees F.	Lb.	Minutes	Lb.	Percent
1.5	200	8.8	20	4.4	50
			30	5.6	64
			40	6.2	70
			60	5.4	61
		8.3	25	5.5	66
			35	6.4	77
			50	5.9	71
			70	5.4	65
		7.6	28	5.0	66
			36	5.3	70
			42	5.0	66
3.0	200	8.0	10	4.5	56
			15	5.3	66
			20	5.2	65
			30	4.7	59
		7.8	12	3.7	47
			17	4.3	55
			22	3.8	49
			27	3.8	49
1.5	180	8.1	30	[3]	-
			45	4.2	52
			60	4.3	53
			70	4.3	53
1.5	240	7.4	10	2.5	34
			15	4.9	66
			20	5.8	78
			30	5.1	69

1/ DIGESTION TIME INCLUDES 10 MINUTES TAKEN TO REACH THE DESIRED TEMPERATURE.

2/ EFFICIENCY OF OIL RECOVERY = $\frac{(\text{OIL RECOVERED})}{(\text{OIL CONTENT OF RAW MATERIAL})} 100$

3/ DIGESTION INCOMPLETE.

recovered oils, it was impossible to draw any significant conclusions concerning the effects of different processing procedures on vitamin A recovery.

The data for each series, except possibly those at 180° F., indicate that there is an optimum digestion time for maximum oil recovery. Presumably the amount of recoverable oil increases rapidly as the flesh disintegrates. The flesh appears to be all digested after one-half to two-thirds of the optimum time; at that point the recoverable oil amounts to about four-fifths of the maximum. After the optimum time, the amount of recoverable oil decreases slowly. When the digestion is continued for twice the optimum time, the oil recovery has only dropped to four-fifths of the maximum. Thus the rates of increase just before and of decrease after the optima times are not comparatively large, and the optima times can hardly be considered critical.

Although additional research will probably bring improvements in the process, the available data on the alkali digestion of salmon waste warrants serious consideration by the industry. With 1.5 parts of sodium hydroxide per 100 parts of waste the digestion at 200° F. was comparatively simple and easy to control. The equipment and manpower costs would be reasonable, and the product would be of good quality. From a canning line packing 200 cases of canned salmon per hour, about 5,000 pounds of waste per hour would be recoverable. As approximately 75 minutes would be sufficient time for each batch operation, digestion and settling tanks with a total capacity of 3,000 gallons would be adequate to handle the waste. As only the top oil-rich layer would need be handled, a 200-

to 400-gallon-per-hour centrifuge would generally be sufficient. If the equipment were arranged efficiently, not over two men would be required to handle the operations. At the oil recovery rate found in this study, the process would convert 5,000 pounds of troublesome pink-salmon waste into 300 pounds of salable oil per hour.

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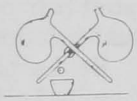

FISH PROCESSING HANDBOOK FOR THE PHILIPPINES

Fish is second only to rice as a food in the Philippines. This handbook, intended for both home and commercial processors of Philippine fishes, covers the handling of fresh fish, the various methods of preserving fish--freezing, salting, drying, smoking, canning, and miscellaneous methods such as pickling--and the spoilage of fish and fish products. It gives a step-by-step description of Philippine fish-preserving methods with suggestions on improving them, and of methods used in other parts of the world which have been adapted for Philippine use by the Philippine Fishery Program of the U. S. Fish and Wildlife Service. Tables of useful data for fish processors and of drawings of common species of Philippine fish are included.

By Arthur C. Avery. Research Report No. 26. Fish and Wildlife Service, Washington, D. C. (1950), 149 pages. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 50 cents.