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POTENTIAL BYPRODUCTS FROM ALASKA FISHERIES: UTILIZATION OF SALMON EGGS AND SALMON WASTE

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ABSTRACT

THE PRESENT LACK OF UTILIZATION OF THE VAST QUANTITIES OF ALASKA SALMON TRIMMINGS AVAILABLE AS WASTE IS CAUSED PRIMARILY BY THE REMOTE AND WIDELY-SEPARATED LOCATIONS OF THE INDIVIDUAL CANNERIES. THIS ARTICLE DISCUSSES THE PAST AND PRESENT METHODS OF USING A RELATIVELY SMALL QUANTITY OF THE TRIMMINGS AND POINTS OUT THE POTENTIAL OF THE WASTE MATERIAL IN INDUSTRIAL PRODUCTION. IT IS SUGGESTED THAT ENZYMATIC DIGESTION, IF PROVED TO BE PRACTICAL BY FURTHER RESEARCH, MAY HELP TO OVERCOME PROBLEMS INHERENT IN ESTABLISHMENT OF AN ALASKA SALMON-WASTE INDUSTRY.

INTRODUCTION

Commercial canning started in Alaska in 1878 with the production of 8,000 cases of salmon. The industry grew steadily. In 1914 it packed 4 million cases (almost 200 million pounds) of salmon, and dumped an estimated 100 million pounds of offal into the sea. In that same year, however, the first plant in Alaska to utilize cannery waste was built near Ketchikan. This plant produced salmon-offal meal and oil. Since 1914, little progress has been made toward efficient and economical utilization of the waste. During 1954, for example, 3 million cases of salmon were packed, yet an estimated 60 million pounds of offal was discarded. During the 1957 canning season, no use was made of salmon offal for reduction purposes.

In contrast to the lack of utilization of salmon offal is the complete utilization of offal in the meat-packing industry, where "the packer saves everything but the squeal." The byproduct branch of that industry, however, has developed around the larger meat-packing centers. Thus it was only when the offal could be collected in substantial quantities--with the growth of large-scale plants for packing meat--that efficient use could be made of all the potential byproducts.

With the decline in size of Alaska salmon runs in recent years, there has been some consolidation of canning operations. Nevertheless, salmon-canning plants still are scattered along a coastline that is longer than the distance from New York to Los Angeles and are hidden, in many instances, in locations remote from normal routes of travel. Furthermore, the canning season in Alaska is short, most canneries operating less than two months of the year.

For salmon-cannery offal to be economically available for the manufacture of byproducts, it must be obtainable either in large quantities, as in Ketchikan where several canneries are located, or it must contain components so valuable that they justify the high cost of collecting.

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The purpose of this paper is (1) to discuss the present use made of salmon waste from the canneries of Alaska, (2) to point out some of the potential uses of the waste and particularly of the eggs as industrial raw materials, and (3) to suggest the use of enzymes as a possible means for preparing soluble protein mixtures from salmon waste.

PRESENT USE

FISH-HATCHERY FEED: In 1956, 100,000 pounds of salmon viscera was collected from two canneries in Petersburg and frozen. The viscera were marketed principally as fish-hatchery feed in Washington and Oregon. The development of this use for cannery offal was based on the results of fish-feeding tests conducted at the Leavenworth hatchery of the Bureau of Commercial Fisheries (Burrows, Robinson, and Palmer 1951; Robinson, Palmer and Burrows 1951; and Robinson, Payne, Palmer and Burrows 1951). Data from the Leavenworth tests indicated that salmon viscera produced a growth response superior to any meat product tested. The response of the hatchery fish to salmon eggs exceeded even that obtained with the viscera. Here a unique quality of the viscera and eggs may be great enough to make their recovery economically attractive. The methods of separating, packaging, and transporting salmon viscera are discussed by Landgraf, Miyauchi, and Stansby (1951).

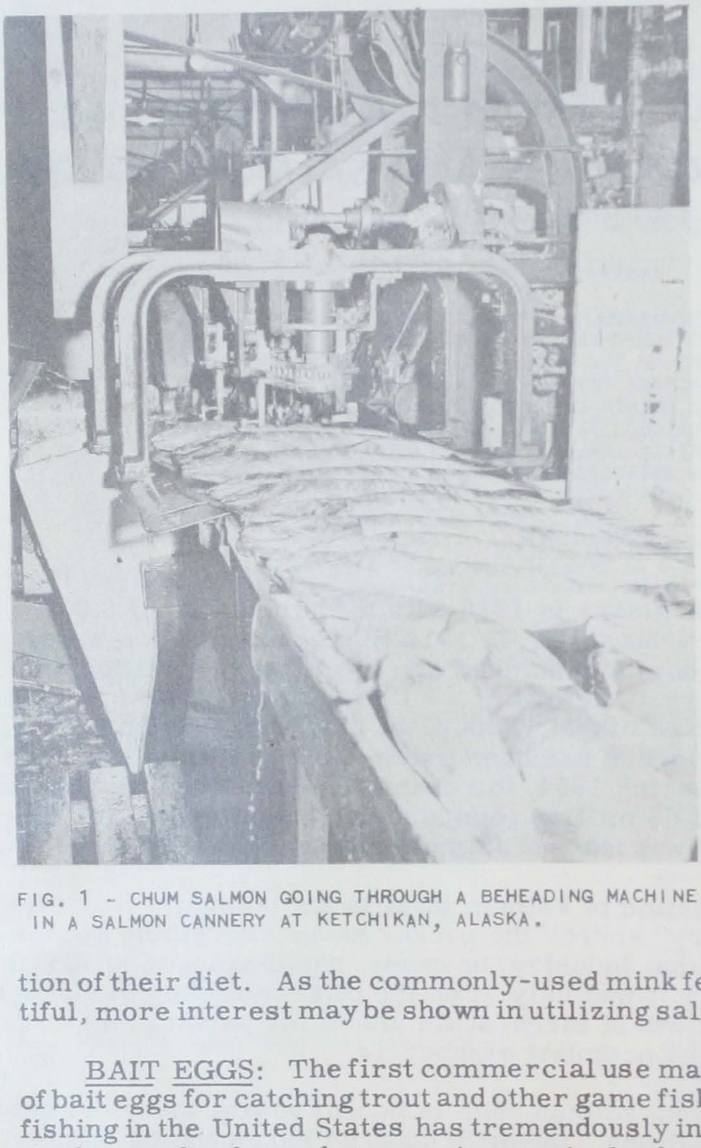

FIG. 1 - CHUM SALMON GOING THROUGH A BEHEADING MACHINE IN A SALMON CANNERY AT KETCHIKAN, ALASKA.

MINK FEED: The use of salmon offal for mink feed was investigated by Leekley, Landgraf, Bjork, and Hagevig (1952). The mink gained in weight when fed frozen salmon offal as the main portion of their diet. As the commonly-used mink feed--horsemeat--becomes less plentiful, more interest may be shown in utilizing salmon-cannery waste for this purpose.

BAIT EGGS: The first commercial use made of salmon eggs was the preparation of bait eggs for catching trout and other game fish (Jarvis 1950). The growth of sport fishing in the United States has tremendously increased the demand for salmon eggs. As the supply of eggs becomes increasingly short in Washington and Oregon, more use is being made of the large amount of Alaska salmon eggs. In 1954, several thousand pounds were processed in Southeastern Alaska for use as bait.

CAVIAR: Cobb (1931) reported that the Russians in Siberia made an excellent caviar from salmon eggs. This "red caviar," as distinguished from sturgeon or "black caviar," has found a good market in the U.S.S.R. as well as in various European countries. Jarvis (1950) describes methods for preparing caviar from salmon. In 1956, a small quantity of salmon eggs from Alaska was marketed as caviar. An additional food product has been suggested by Carlson (1955), who developed a sandwich spread from smoked salmon eggs.

POTENTIAL USES

Stansby and associates (1953a) carefully investigated the potentialities of salmon-cannery offal and salmon eggs as industrial raw materials. Many ways were suggested for recovering valuable constituents. They (1953b) discussed the possibilities, for example, of producing proteins, protein hydrolysates, and amino acids from cannery offal. The remote location of the canneries and the lack of processing facilities for the manufacture of such commodities, however, were stressed as factors that make the economical recoveries of these materials difficult. Additional work in Bureau of Commercial Fisheries laboratories has been directed towards the determination of components which might have industrial value.

Table 1 - Component Fatty Acids of Pink Salmon Egg Oil, Cottonseed Oil, and Beef Fat

Fatty Acids	Salmon-Egg Oil		Cottonseed Oil1/	Beef Fat1/
	Free-Oil Drop	Total Oil		
Saturated:	(Percent)			
C_{14}	1.8	0.6	3.0	3.0
C_{16}	8.3	9.5	20.0	29.2
C_{18}	1.9	3.9	1.0	21.0
C_{20}	-	-	1.0	0.4
Unsaturated:				
C_{14}	0.1	0.1	-	0.6
C_{16}	5.1	8.1	-	2.7
C_{18} oleic	10.5	1.7	30.0	41.1
C_{18} higher unsaturated	30.8 (4.4H)	26.1 (3.5H)	45.0 (4.0H)	1.8 (4.0H)
C_{20}	31.1 (7.3H)	27.0 (9.0H)	-	0.2
C_{22}	14.7 (11.8H)	19.0 (10.6H)	-	-
C_{24}	0.2	-	-	-
Unresolved	5.5	3.7	-	-

1/HILDITCH 1941.
NOTE: THE NUMBERS IN PARENTHESES ARE A MEASURE OF UNSATURATION AND INDICATE THE ATOMS OF HYDROGEN REQUIRED TO SATURATE THE FATTY ACIDS COMPLETELY.

On a tonnage basis, the largest use of Alaska salmon waste has been in the production of meal and oil. At the present time, no salmon-offal reduction plants are operating in Alaska.

OIL FRACTION: Salmon eggs comprise 3 to 30 percent of the cannery offal (Magnusson and Hagevig 1950), depending on the species of salmon and its maturity.

The salmon egg is a large single cell consisting of a soft shell, a protein solution, and a droplet of oil floating on the protein solution. Sinnhuber (1943) developed a method of recovering the oil droplet from salmon eggs. Kyte (1956) determined the constituent fatty acids of this oil. This free droplet, however, represents only one-third of the total oil in the salmon egg. The other two-thirds apparently is associated closely with the protein of the egg, in that it is not liberated by the Sinnhuber method. In later unpublished work by Kyte, the fatty acids in the total oil of pink salmon eggs are determined. Data on the fatty acids in the total oil and in the oil droplet are shown in table 1 together with comparative data for cottonseed oil and beef tallow.

It will be noted from table 1 that salmon-egg oils contain about 45 percent fatty acids with molecules having 20 to 22 carbon atoms--fatty acids not normally found in significant quantities in vegetable or land-animal fats. These long-chain fatty acids in salmon-egg oil are highly unsaturated. Active research is being carried out by Bureau of Commercial Fisheries laboratories (Anonymous 1955), to take advantage of these characteristics in the preparation of new compounds of potential commercial value.1/

Stansby and associates (1953c) reported that approximately one-third of the total oil of salmon eggs is a phospholipid, probably lecithin. Vegetable lecithins are used industrially as wetting and emulsifying agents, moisture absorbents, and antioxidants in both food and nonfood industries. The fatty acids associated with the lecithin from salmon eggs are more highly unsaturated and have a longer carbon chain than have those found in vegetable lecithin.

1/C_{20} AND C_{22} FATTY ACIDS REPORTED IN SEVERAL MARINE ANIMAL OILS ARE: COD LIVER, 35.0 PERCENT; HERRING, 45.0 PERCENT; MENHADEN, 32.0 PERCENT; PILCHARD, 31.7 PERCENT; SALMON, 39.7 PERCENT; SARDINE, 41.0 PERCENT; SHARK LIVER, 32.5 PERCENT; AND WHALE, 17.7 PERCENT. THUS SALMON-EGG OIL CONTAINS MORE C_{20} AND C_{22} FATTY ACIDS THAN DO MOST OTHER COMMERCIAL MARINE-ANIMAL OILS.

The properties of salmon-egg lecithin have not been investigated extensively. Stansby and associates (1953c) also found 4 to 7 percent unsaponifiable matter in the total oil from salmon eggs. About half of this unsaponifiable matter is cholesterol. Cholesterol is used in the manufacture of synthetic vitamin D and certain hormones.

PROTEIN FRACTION: The amino acid content of the protein fraction of salmon eggs was investigated by Seagran, Morey, and Dassow (1954). These workers reported the amount of each of 10 essential amino acids found in the eggs of the five Alaskan species of salmon at various stages of maturity. Table 2 gives the average

Table 2 - Amount of the Ten Essential Amino Acids in the Protein of Salmon Eggs, Soybean Meal, and Cottonseed Meal

Amino Acids	Salmon Eggs	Soybean Meal	Cottonseed Meal
	.........(Percentage of Protein).........		
Arginine	7.2	7.3	11.3
Histidine	2.7	2.9	2.7
Isoleucine	7.2	6.0	4.0
Leucine	9.9	8.0	6.0
Lysine	8.8	6.8	3.5
Methionine	2.9	1.7	1.7
Phenylalanine	4.8	5.3	6.0
Threonine	5.9	3.9	3.0
Tryptophan	0.9	1.4	1.3
Valine	7.2	5.3	4.8

content of these amino acids in the protein of mature salmon eggs and, for comparison, the amino acid content of the protein of soybean meal and cottonseed meal. The data show that the essential amino acids are present in good amount in salmon eggs. Of particular interest are the levels of lysine, isoleucine, and methionine--the amino acids needed for supplementation of vegetable-protein concentrates in animal nutrition.

ENZYME DIGESTION

Anderson (1945) worked on the possibility of using alkali digestion to recover oil from salmon-cannery waste. A somewhat different approach was taken by Idler and Schmitt (1955), who reported enzymes effective in solubilizing a large portion of the waste from shrimp-processing plants. Kyte (1956) reported that enzyme digestion of salmon eggs was effective in solubilizing salmon-egg protein, thus aiding a gross separation of the oil from the protein.

It is proposed that enzymes acting on the entire offal from a salmon cannery may enable the cannery operator, with very little additional equipment, to prepare slurries of crude oil and protein. This mixture could be collected after the seasonal canning operations, and could be combined and processed with similar materials from other canneries in a central byproducts plant.

Although considerable field testing and an economic study would be necessary in order to evaluate enzyme digestion of fish waste, this process may enable a processor to secure adequate raw materials to make economically feasible a greater production of byproducts from Alaska salmon waste.

SUMMARY

Approximately 60 million pounds of offal from Alaska salmon canneries is being discarded annually. The remote locations of the canneries tend to discourage the collection of large amounts of waste, evidently because potential industries feel that

this situation will not permit the economical collection and manufacture of byproducts. Such use as is made of the waste at present is in the manufacture of a limited amount of fish-hatchery feed, mink feed, bait eggs, and caviar. The possibility exists, however, that valuable uses may be found for the oil and protein fractions of salmon offal.

About one-third of the oil in the salmon egg is in the form of a free-oil droplet. The other two-thirds is closely associated with protein. Salmon-egg oil contains about 45 percent fatty acids with molecules having 20 and 22 carbon atoms. These molecules are highly unsaturated. Approximately one-third of the total oil is phospholipid, probably lecithin, and approximately 4 to 7 percent of the total oil is unsaponifiable matter, half of which is cholesterol.

The essential amino acids are present in good amount in salmon eggs. Of particular interest is the content of lysine, isoleucine, and methionine, which are needed for supplementation of vegetable-protein concentrates in animal nutrition.

It is proposed that enzymes acting on salmon-cannery offal may enable a cannery operator, with little additional equipment or labor, to prepare an oil-and-protein slurry. Such a process would require additional research, but if proved practical, could offer a partial solution in encouraging more complete utilization of salmon waste.

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