OXIDATIVE DETERIORATION IN FISH AND FISHERY PRODUCTS

Part 1 - Introduction

By M. E. Stansby*

ABSTRACT

HEMATIN COMPOUNDS ARE SHOWN TO PLAY A MAJOR ROLE IN PROMOTING OXIDATION OF OIL IN FISH TISSUE. ANTIOXIDANT MIXTURES OF FAR GREATER EFFECTIVENESS THAN WAS PREVIOUSLY KNOWN HAVE BEEN DEVELOPED FOR RETARDING OXIDATION OF OIL IN THE MEAT OF FISH. ANTIOXIDANT TREATMENT OF FISH MEAL HAS BEEN STUDIED.

BACKGROUND

Oxidation of fish oils, when occurring spontaneously, causes great deterioration in the quality of a variety of fishery products. The oxidation of the oils and of the associated pigments in fish meat causes rancidity and discoloration in fresh, canned, preserved, and especially frozen fish. Oxidation of that part of the oil left in fish meal causes heating of the meal, and certain so-far unidentified reactions take place which apparently impair the nutritive value of the meal. Oxidation of rendered fish oils alter their properties and result in off-odors.

FIG. 1 - EMULSIFYING MENHADEN OIL FOR OXIDATION STUDIES AT THE FOOD TECHNOLOGY LABORATORY, UNIVERSITY OF CALIFORNIA, DAVIS, WHERE A PORTION OF THE PROGRAM ON OXIDATIVE DETERIORATION OF FISHERY PRODUCTS IS BEING CARRIED OUT.

A collaborative program is under way between the U. S. Fish and Wildlife Service and the University of California Department of Food Technology to investigate various aspects of the oxidation problem. The work, at present, covers four phases, which will be discussed briefly in this introductory paper; each phase then will be described in greater detail in succeeding papers.

The program is being carried out both at the Davis and at the Berkeley laboratories of the Food Technology Department of the University of California. At Davis, the program, which is under the immediate supervision of Professor A. L. Tappel, is being carried out in the new Food Technology building, which possesses excellent facilities for application of research on the chemistry of foods to practical problems of the food industry. The Fish and Wildlife Service has one full-time and one part-time chemist who are stationed at Davis in the laboratories of the Food Technology Department and who are working on this program. Since July 1, 1956, the Institute of Marine Resources of the University of California has had a laboratory in the Food Technology Department at Berkeley. The Fish and Wildlife Service has a full-time and a part-time chemist working on the program in this laboratory under Professor Harold Olcott. These programs come under the general supervision of the Seattle Fishery Technological Laboratory of the U. S. Fish and Wildlife Service. The pro-

*CHIEF, PACIFIC COAST AND ALASKA TECHNOLOGICAL RESEARCH, FISHERY TECHNOLOGICAL LABORATORY, BRANCH OF COMMERCIAL FISHERIES, U. S. FISH AND WILDLIFE SERVICE, SEATTLE, WASH.

NOTE: THIS SERIES REPLACES THE ONE STARTED IN THE FEBRUARY 1956 ISSUE (P.10) OF COMMERCIAL FISHERIES REVIEW TITLED "OXIDATIVE DETERIORATION IN FISH AND FISHERY PRODUCTS--NO. 1."

gram has been concerned principally with four fields of study: (1) mechanism of oxidation of oil in fish tissue; (2) reaction of fish oil and protein while in fish tissue or in fish meal; (3) oxidation of extracted fish oil; and (4) oxidation of pigments in tuna.

FIG. 2 - GENERAL VIEW OF FISHERY TECHNOLOGICAL LABORATORY OF THE INSTITUTE OF MARINE RESOURCES, UNIVERSITY OF CALIFORNIA, BERKELEY, WHERE A PORTION OF THE PROGRAM ON OXIDATIVE DETERIORATION OF FISHERY PRODUCTS IS BEING CARRIED OUT.

OXIDATION MECHANISM IN FISH TISSUE

In the program on the mechanism of oxidation of oil in fish tissue, it has been shown that the hematin blood of pigments are probably of major importance as catalysts in accelerating the oxidation of oil in fish. The amounts of these pigments in a number of species of fish have been measured. It has been shown that the oxidation of oil occurs much more rapidly in those localized areas in the fish tissue where these hematin pigments are concentrated. Model systems have been set up, and the effectiveness of numerous antioxidants, alone and in combination, toward retarding oxidation has been investigated; certain combinations have been found that are many times as effective as are the individual antioxidant components. The effectiveness of commercial antioxidants added to fish meals also has been studied.

FISH OIL-PROTEIN REACTION

The reaction between oil, oxygen, and protein in fish results in such phenomena as rusting in frozen fish and darkening of the color of fish meal. The mechanism of this reaction has been investigated, and it has been found that two types of reactions are involved: oil oxidation and the carbonylamine reaction. Evidence has been obtained to show that the former reaction predominates and that factors influencing oxidation are of primary importance in retarding this oil-protein reaction.

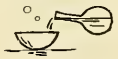
OXIDATION OF EXTRACTED OILS

The role of the naturally-occurring antioxidants, the tocopherols, in extracted oils is being investigated. These occur in small concentrations in all of the fish oils

studied. Added tocopherols are not particularly effective antioxidants, but the naturally occurring tocopherols may play an important role in determining stability. Certain commercial antioxidants can exert a considerable effect on the retardment of oxidation of extracted oils. The same antioxidants that exert the most powerful action in retarding oxidation of oil in fish tissue are not necessarily the best for use with extracted oils. Each substance or combination of substances must be assayed separately in the different systems.

PIGMENT CHANGES IN TUNA

It has been shown (1) that the normal change in the color of tuna--from the neutral shade in the raw fish to the desirable pink color after precooking and thence, under unfavorable circumstances, to an undesirable tan shade-- results from a series of oxidation reactions of hematin blood and muscle pigments and (2) that the reaction of the pink to the tan pigment is, under suitable conditions, reversible. The formation of the pink color is favored by the presence both of reducing conditions and of nicotinamide. Strong evidence that the pink pigments are denatured globin hemochrome or nicotinamide hemochrome, or both, has been obtained.



WHALE MEAT AN IMPORTANT FOOD IN SOME COUNTRIES

The people of Japan and the Faeroe Islands habitually eat whale meat and so do some aboriginal peoples, including the Eskimos. In England, Norway, and Canada some whale meat has been produced, and in the United States it has appeared on the menus of seafood restaurants, as a novelty item.

In the Faroe Islands, which lie in the North Atlantic between Iceland and Great Britain, whale meat is a very important item of food. Almost all of the animal is eaten. Some of the meat is eaten fresh while some is dried for future consumption. Pieces of black dried whale meat are a common sight hanging up outside the homes of the Faroese people.

The method which the Faroese use in capturing the whales is also of interest. When a school of whales are sighted at sea near the islands the person sighting the school arouses the inhabitants of the nearest community who encircle the school in boats and gradually drive the whales into the nearest fjord. The whales are slaughtered in the shallow water at the head of the fjord and the meat shared among all the inhabitants of the area. The whale hunt is a great social occasion in the islands and it is always followed by dancing. The customs relating to the division of the meat are very rigid and have apparently been in existence for a considerable length of time.

--"Sea Secrets," The Marine Laboratory, University of Miami.