IRON SULFIDE DISCOLORATION OF TUNA CANS[1]

No. 3 - Effect of Variables Introduced by the Fish

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INTRODUCTION

During recent years, certain batches of solid-pack canned tuna have developed an iron sulfide formation on the can area adjacent to the headspace. This paper is the third in a series of six papers in which an investigation of the problem of can discoloration is being reported (Pigott and Stansby 1955).

The degree of spoilage, the length of time that the fish are held in cold storage, and the species of tuna canned are the three primary variables introduced into the canning process attributable to the fish itself. The objective of this paper is to report the results of an investigation of these three variables.

SOURCE OF COMMERCIAL TUNA

Tuna being canned by American packers is from two major sources: the Pacific Ocean off the west coast of the United States and off the northern portion of South America, and the western and central Pacific Ocean.

Experimental fish in retorts for precooking.

Tuna caught off the coasts of the United States and South America are taken by pole and line, by trolling, and by purse-seining. Most of the larger vessels are equipped with freezing brine-tank facilities so that the fish may be frozen shortly after being caught. The freezerships remain on the fishing grounds until the catch is considered a "payload" (a few weeks to several months) before delivering the fish to the canneries. Vessels using ice to preserve the catch are generally out of port about two weeks. These iced fish, referred to as "local fish," are usually packed as soon as they are received at the cannery.

The Japanese fishing fleet accounts for most of the tuna caught in the western and central Pacific Ocean. The Japanese tuna fishery is quite different from that of the United States, owing primarily to the distances the boats must travel and to the depth at which the fish are found. The fish are usually caught by pole and line and by long-lining (Shapiro 1948). Large motherships, equipped with freezing and storage facilities, accompany the fishing fleets to sea and receive the fish from catcher boats. The frozen tuna is taken to Japan where the fish destined to be sold to United States buyers is sorted by size and species and is held in cold storage for shipment.

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COMMERCIAL CANNING OF TUNA

Tuna packing is unique among fish-packing operations in that tuna is given a preliminary steam cook (called the precook) before it is canned. The purpose of the precook is to remove the tuna oil and make the fish easier to clean. Frozen tuna is thawed and butchered before being precooked. The butchering consists of removal of viscera and gills.

Successful precooking of tuna depends largely on the ability of the operator to judge the condition of the raw fish. Such variables as oil content and initial temperature of fish have a bearing on the optimum precook. The time of precook varies from 1 to 2 hours for a very small fish to 8 to 10 hours for a very large fish. The temperature of the cooker normally varies from 212° to 220° F. It is important not to bring the cooker temperature up too rapidly or the skin breaks and the meat tissues are injured.

After being precooked, the tuna are cooled--usually overnight--and then cleaned in preparation for packing into the can. This cleaning step consists of removing the head, scraping off the skin, and splitting the fish into four longitudinal loins at which point the backbone is removed. Dark meat and blood are scraped from the section of the loin adjacent to the backbone and to the lateral line. For production of the solid pack, the cleaned loins are then cut into sections that will fit into the cans.

Tuna is normally packed in $\frac{1}{2}$-pound tuna cans designated as 307 x 113 ($3\frac{7}{16}$ inches diameter and $1\frac{13}{16}$ inches high). Approximately $5\frac{1}{2}$ to 6 ounces of meat, $1\frac{1}{2}$ ounces soya or cottonseed oil, and $\frac{1}{8}$ ounce salt are placed into each can. The cans are then closed under vacuum by a can seamer. Most packers retort the closed cans at 240° F. for 75 minutes, after which time the cans are cooled and labeled for marketing.

This outline of tuna packing is very general, since all canners have their own modifications and special techniques in plant operation.

SAMPLES USED IN EXPERIMENTAL WORK

LOCAL ALBACORE: During August 1953, a collection trip was made aboard a tuna vessel off lower California. A total of 74 troll-caught albacore from the commercial catch were tagged for use in sulfide discoloration studies. Three groups of fish averaging 12 to 15 pounds in weight were obtained. The groups were designated as (1) fresh, (2) slightly spoiled, and (3) spoiled.

The fresh fish were caught in the cool of evening and iced shortly after being caught. This group was stored in ice on board the vessel for two days before reaching port. All fish in the group were judged to be in excellent condition when unloaded.

Table 1 - Effect of Precook on Sulfide Content of "Local" Albacore

Sample	Hydrogen Sulfide Content of "Local" Albacore		
	Raw	After $\frac{1}{2}$ Normal Precook	After Normal Precook
	Micrograms Per 100 Gms.	Micrograms Per 100 Gms.	Micrograms Per 100 Gms.
Fresh	16	0	0
Spoiled	26	Trace	0

The fish designated as slightly spoiled were caught in the morning and left on deck approximately 11 hours before being iced. During seven hours of this time the catch was exposed to sunlight (62° to 75° F.). The storage time in ice was four days before reaching port. These fish were judged to be slightly spoiled when unloaded because of a slight off-odor and softness of the meat.

The third group of albacore were caught early one morning and kept on deck until the following morning (approximately 26 hours on deck; 60° to 70° F.). Storage time in ice for this group was 8 days before reaching port. Advanced spoilage was very apparent in this group at the time of unloading. The meat was extremely soft and a very strong odor was detected. The belly cavity of each of these fish gave a strong odor of hydrogen sulfide at the time of butchering.

It should be emphasized that the first two of the above groups of fish were part of the commercial catch for the particular day. That is, these two experimental lots were parts of larger batches which were canned commercially after the fish were landed in San Diego. Every effort was made to duplicate commercial conditions during all phases of catching, handling, and canning of the experimental fish.

The iced fish were quick-frozen immediately after being unloaded in San Diego, Calif., shipped to Seattle, Wash., via refrigerated truck, and stored at -20° F. until needed for experimental work.

The advantage of securing a large batch of tuna of known history, such as this, was that frozen control-samples could be held for all experimental packs. Thus, if an experiment gave significant results, there were always other samples from the same lot with which to extend the studies.

IMPORTED ALBACORE: Imported albacore tuna from Japan were obtained from several canneries. These samples were not as desirable for these experiments as the local albacore, since no information was available as to the catching methods, length of time in cold storage, and other factors.

YELLOWFIN: A large batch of yellowfin tuna was supplied by the Pacific Oceanic Fishery Investigations, U. S. Fish and Wildlife Service. The fish, which ranged from 50 to 150 pounds, were taken by long lines in the South Pacific, frozen, and shipped to Seattle by refrigerated steamer. Tuna from this area that weigh over 120 pounds are often rejected by Hawaiian canners because the meat of the fish develops an off-color after the precook. The off-colored meat ranges from a slightly darker-than-normal to a dark gray-green or brownish-mahogany color.

CANNED COMMERCIAL PACKS: Cans from packs of commercially-canned albacore and yellowfin tuna were obtained from various packers on the West Coast. Samples from "complaint" packs with can discoloration were secured whenever possible.

EFFECT OF SPOILAGE

After fish have been caught, the proteinaceous materials in them deteriorate rapidly, owing to the action of bacteria and enzymes. Therefore, if fresh fish are not frozen or canned soon after being taken from the water, changes take place that are detrimental to the quality of the fish. A series of experiments were carried out to determine the effect of spoilage.

SPOILAGE PRIOR TO PRECOOKING: Sulfide content was determined immediately prior to precooking on two samples from two groups of "local" albacore tuna. One group had been frozen when fresh; the other had been frozen when somewhat spoiled. The fish in each group were then divided into two subgroups, one subgroup being precooked the normal time and the other being precooked one-half the normal time. All samples were again analyzed for hydrogen sulfide after the meat had cooled and was ready for canning. The results, given in table 1, show that precooking drives the free sulfide from the meat so that the fish, as it is ready for canning, contains no loosely-bound sulfide. Throughout this investigation, no free sulfide was found in the many samples of both albacore and yellowfin that were analyzed for sulfide after the fish were precooked and ready for canning.

Raw albacore and yellowfin at different stages of deterioration were precooked and then packed in single-enamel cans of the same type that were used by industry[1] when the initial outbreaks of sulfide discoloration occurred. In no instance did spoilage of the raw fish cause worse can discoloration than that found with the fresh fish.

SPOILAGE AFTER PRECOOKING: A pack similar to that described above was canned in order to determine whether spoilage occurring in precooked fish had any effect on can discoloration. Albacore and yellowfin were precooked and allowed to stand, at room temperature, for periods up to 4 days and, at 32° F., for periods up to 2 weeks before being canned. These fish showed no signs of spoilage at this stage except for the development of some rancidity in the dark meat. As in the case when the raw fish were spoiled, fish spoiled after precook had no effect on can discoloration.

EFFECT OF TIME IN COLD STORAGE

The fish used in experiments in which the effect of spoilage was investigated had been in cold storage for a period of about one month. Another series of experiments were run in which fish were canned after various periods of cold storage in order to determine whether the oxidation or dehydration that takes place during cold storage had some effect on can discoloration.

The samples of local albacore that were used in this investigation showed no signs of causing can discoloration when canned at intervals up to 14 months. After this group of fish had been in cold storage for 14 months, however, can discoloration was noted when the fish were canned as solid packs.

It was also noted that the groups of albacore that had been spoiled before being frozen and then held for 14 months in the frozen stage caused worse can discoloration than did the group of albacore that was frozen when fresh and then stored.

The yellowfin used in these experiments caused can discoloration to a slight extent when a solid pack was made after one month of cold storage. As these fish were kept in cold storage for longer periods of time, the solid packs prepared from this lot at intervals showed increasing can discoloration.

EFFECT OF SPECIES

In this investigation of iron sulfide discoloration of tuna cans, only raw albacore and yellowfin tuna were used for canning experimental packs. All imported albacore from Japan caused very bad discoloration when packed in single-enamel cans. Yellowfin from the central Pacific also caused discoloration but not as much as did the imported albacore. The local albacore did not cause discoloration until it had been in cold storage for 14 months, after which time the discoloration was comparable to that of the imported albacore. The imported albacore had doubtlessly been held in frozen storage for an extended period of time when they were received, but, unfortunately, the exact storage time was not known.

CONCLUSIONS

From the work reported in this paper, the following conclusions are apparent:

1. Essentially all of the free sulfides in the meat of raw tuna, regardless of the degree of freshness of meat, were driven off during the precook.

1/ Unless otherwise stated all tuna canned throughout this investigation were canned as solid packs in these single-enamel cans so that maximum discoloration would be produced where such an effect had occurred.

2. Of the samples used in this work, spoilage either before or after precooking had no effect on discoloration unless the fish were subsequently stored for extended periods in which case the spoiled fish caused somewhat greater discoloration.

3. Increasing the length of time the fish were in cold storage increased the tendency for tuna to cause can discoloration.

4. With the samples of tuna used in this work, the length of time in cold storage had more effect on can discoloration than did the species.

LITERATURE CITED

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NEW ARTIFICIAL ICE

A new type of artificial ice is being used for chilling perishable foods prior to their distribution. The ice is made up of cold-retaining substances in a colloidal solution held in gel base and it does not evaporate or melt into liquid under the conditions in which the foods are handled. By modifying the chemical formula, the refrigerant can be frozen at -1.1° C., -12.2° C., and -22.2° C. (30°, 10°, and -8° F.), the freezing time being the same as that of water. The ice has been reported to be used 120 times during a period of 4 months by refreezing. It is said to lose its chilling qualities slowly, thereby insuring an even refrigeration of the product.

--National Provisioner, August 15, 1953.