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RECORDING COLOR CHANGES IN FROZEN PINK SALMON

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In studying the progress of deterioration in frozen pink salmon, it was found that there was a considerable change in color of the cut surface of the steaks. During storage studies with frozen fish, Stansby and Harrison (1942) found that the normal pink to red color of the surface of pink salmon (Oncorhynchus gorbuscha) fillets would fade, turn yellowish, and otherwise assume discolored tints of various degrees of intensity until the fillets were no longer marketable. Inasmuch as these alterations in color indicate a corresponding deterioration of the flavor and odor of the flesh, it may be a highly important index to both the processor and the consumer.

As a part of an investigation (authors, 1946) on the keeping qualities of frozen packaged pink salmon steaks, a study was made of the effect of treatment of steaks with brine and brine-sodium nitrite mixture on changes in surface color. These two kinds of steaks and an untreated control were observed at intervals during a nine month storage period. The method employed for recording and evaluating the color of the flesh was that previously described by the authors (1942) in which color photographs are taken, the transparencies placed in a spectrophotometer, and the spectral distribution curves are obtained.

APPARATUS

Equipment used for recording the color was modified slightly from that originally described by the authors. An Eastman 35 mm. camera with f 3.5 anastigmatic lens with attached Eastman + 3 portrait lens was rigidly fastened to the top of a closed box. This combination of lenses permitted sharp focusing at 11.5 inches. At this distance a false bottom in the box supported a wooden tray approximately 8 by 9 inches; this tray was divided into two sections and painted white. With one 3200° Kelvin lamp located at the upper edge of the box near the camera and illuminating the area through a 3 by 9 inches piece of opal flash glass, the correct exposure was 1/50 second at f 3.5 using Type A Kodachrome film. Current for the lamp was supplied through a 110 volt autotransformer.

The color film was processed by the manufacturer and returned in 2 by 2 inches cardboard mounts. A slide carrier was made from sheet micarta to fit the cuvette chamber on a Coleman Universal Spectrophotometer to enable transmission measurements to be made on each half of the transparency.

EXPERIMENTAL PROCEDURE

All steaks were prepared in the same manner from whole pink salmon less than 24 hours after removal of the fish from water. Steaks were cut approximately one inch in thickness by commercial operators after the fish had been dressed, scaled and washed. After pretreatment, steaks were wrapped in Dupont No. 300 moisture-vaporproof cellophane, packed in five pound size waxed cartons, quick frozen in a plate freezer, and stored at 0°F. (plus or minus 3°F.).

Pretreatments were as follows:

1. Untreated.
2. Steaks dipped for 20 seconds in 5 percent sodium chloride solution (20° brine).
3. Steaks dipped for 20 seconds in 5 percent sodium chloride-0.5 percent sodium nitrite solution.

Samples were withdrawn for observation after three, six and nine months of storage. After thawing the steaks overnight in a closed container at room temperature, notes were made on their appearance.

Due to differences in the flesh color of the individual fish from which the steaks had been prepared, it was not practical to compare the faded surface of steaks from one series directly with that of another in recording the color changes. In order to record the color changes of steaks in each series, four or five typical steaks were sectioned parallel to the surface cut to expose the internal color of the flesh. Since the color changes were confined to the surface of the steaks during the entire storage period, the color of this freshly cut surface closely approximated the initial color of the steaks before storage. Half of the steaks were arranged in one part of the tray with the faded surface uppermost, and these were cut to fit at the corners in order to eliminate air spaces. The other half were similarly arranged in the second part with the fresh inner cut uppermost, thus giving a control exposure showing the initial color of the steaks on the same film. At each periodic examination exposures of steaks from each series were made on a single roll of film; the exposed film was returned to the factory for processing.

To analyze the color characteristics of each sample, the color transparency was examined in the spectrophotometer and a spectral distribution curve of the transmission readings was plotted. The readings were made at 25 millimicron intervals throughout the spectrum of 400 to 800 millimicrons of wavelength. The transmission readings for the outside surface of the steak and the fresh cut surface were made alternately at each wavelength. The readings for both surfaces were plotted on the same graph sheet in order to disclose all significant differences.

EXPERIMENTAL RESULTS

In order for the results of the method to be considered valid, the following information was affirmed during the course of the experiments:

1. Since the color of the fresh inner cut of each steak was used as the estimate of initial color, it was necessary to determine that any color changes in the steaks as a result of storage were limited to the initially cut surface of the steak. At each examination steaks cut from frozen whole (in the round) salmon were compared to the fresh inner cuts of the packaged steaks. In no case was the variation outside the normal limits of color variability. Storage of packaged pink salmon steaks for a period of fifteen months was found to be necessary before color changes affected the entire steak.

2. Transmission data on duplicate exposures of a sample and exposures of duplicate samples from the same series did not show any appreciable differences.

3. The readings of percent transmission of the film were not affected by slight displacement in the holder, and readings were reproducible.

4. The exit slit of the spectrophotometer was slightly smaller than the film surface showing the sample, thus there was no transmission of light through extraneous material.

Data taken after three, six and nine months of storage showed that the surface color of the steaks after six months best illustrated the differences due to treatment. At the end of three months of storage, surface color had not changed sufficiently to be indicative of deterioration. After nine months of storage, there were major changes in color in all three series.

The untreated steaks were severelyfaded and discolored after six months of storage. The spectral distribution curves for this series are reproduced in Figure 1. and show the uniform fading of color in the packaged steaks. The increased transmission of light for the surface color of stored steaks as compared with that of the freshly cut surface indicates the degree of fading that has taken place. The degree of surface discoloration is not readily obvious from the percent transmission curves, although it can be judged in part by the decreased transmission in the red portion of the spectrum at 675 and 700 mu. Presumably, the effect of slight discoloration would be to decrease the high transmission readings caused by loss of color.

The color of the brine-treated steaks faded to about the same degree as that of the controls, but the discoloration was greater with the untreated steaks. Due mainly to this factor, the appearance of these steaks was considered superior to the untreated, however, the transmission readings for the brined steaks (Figure 2) shows a greater loss of color in the red portion of the spectrum (600 to 700 mu). Evidently this is due to the fact that no surface discoloration was present to offset the loss of color. Yellowing of the flesh near the skin was not enough to cause a marked effect on the transmission readings. Also noticeable in the transmission readings for the brined steaks is the fact that the shape of the curve for the faded surface more closely resembles the curve for the color of the freshly cut surface.

The appearance and color of the brine-sodium nitrite-treated steaks at six months were very much superior to both untreated and brined steaks. Aside from a slight yellowing of the edges, the important alteration in appearance was a spotty effect on the surface due to uneven fading and darkening of the color. The graph of these steaks (Figure 3) reflects their superior condition. Except for a moderat increase in the red portion of the spectral curve for the exposed surface, the curv clearly parallel each other. To a certain extent the curve for the surface represents an average because the slightly faded areas tended to balance the areas of slight darkening. It is also noteworthy that both curves for these steaks closely resemble the curve for untreated steaks in Figure 1. The sodium nitrite did not intensify the color of the pink salmon but acted mainly as a preservative. The color of the sodium nitrite-treated steaks after cooking was much more attractive than the color of the untreated steaks.

DISCUSSION

Examination of the figures indicates that the transmission readings for the samples have shown to a considerable degree the effect of the pretreatments on pink salmon steaks. Fading of the normal flesh color caused an increase in transmission readings. In the untreated and brine-sodium nitrite-treated steaks this was offset by decreased transmission readings in the discolored areas. Because no surface discoloration of the samples was present, the curve for the brine-treated steaks represents most accurately the relative effect of the greater fading in the red portion of the spectrum.

The application of this method of color analysis to determining storage changes appears to be limited mainly by the fact that any discoloration and darkening will obscure the actual color change. Conclusions drawn from values obtained under these conditions must be tempered by such modifications as visual observation warrants.

In cases where the shape of the absorption curve is altered, actual changes in the relation of the flesh pigments may be expected. This was shown by other experiments when silver salmon steaks were stored under conditions similar to those of the pink salmon. These steaks were of marketable quality and had not faded to a serious extent, but there was a marked decrease in the transmission readings in the red portion of the spectrum. By closely comparing the color of the exposed surface and that of the freshly cut surface of the steaks, it appeared as if the bright red pigments had been changed to an orange-red color with a slight bluish cast.

Examination of steaks from the other species of salmon has further indicated that the spectral distribution curves of the color of the flesh may be used as a measure of the deterioration which takes place during frozen storage. For example the excellent keeping qualities of either brined or unbrined red (or sockeye) salmon steaks was reaffirmed by the close correlation of the color analysis with the freshness of the product after six months of storage.

Further refinements in the method can undoubtedly be made. The method might be rendered more sensitive by a more uniform manner of arranging the steaks, such as freezing the steaks in a mold suitable for photographing or placing a glass plate on the surface. Also when using fillets, one might package the fillet from one side of the fish for a control and utilize the other fillet for the test treatment. The effects of antioxidants and preservatives could be easily determined in this way. The most important factor in utilizing the method appears to be the use of a control which accurately indicates initial color so changes in color can be accurately estimated.

LITERATURE CITED

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FIG. 1 - PERCENT TRANSMISSION OF LIGHT AT VARIOUS WAVELENTHS THROUGH KODACHROME EXPOSURES OF FROZEN PINK SALMON. UNTREATED CONTROL STORED AT 0°F. FOR SIX MONTHS.

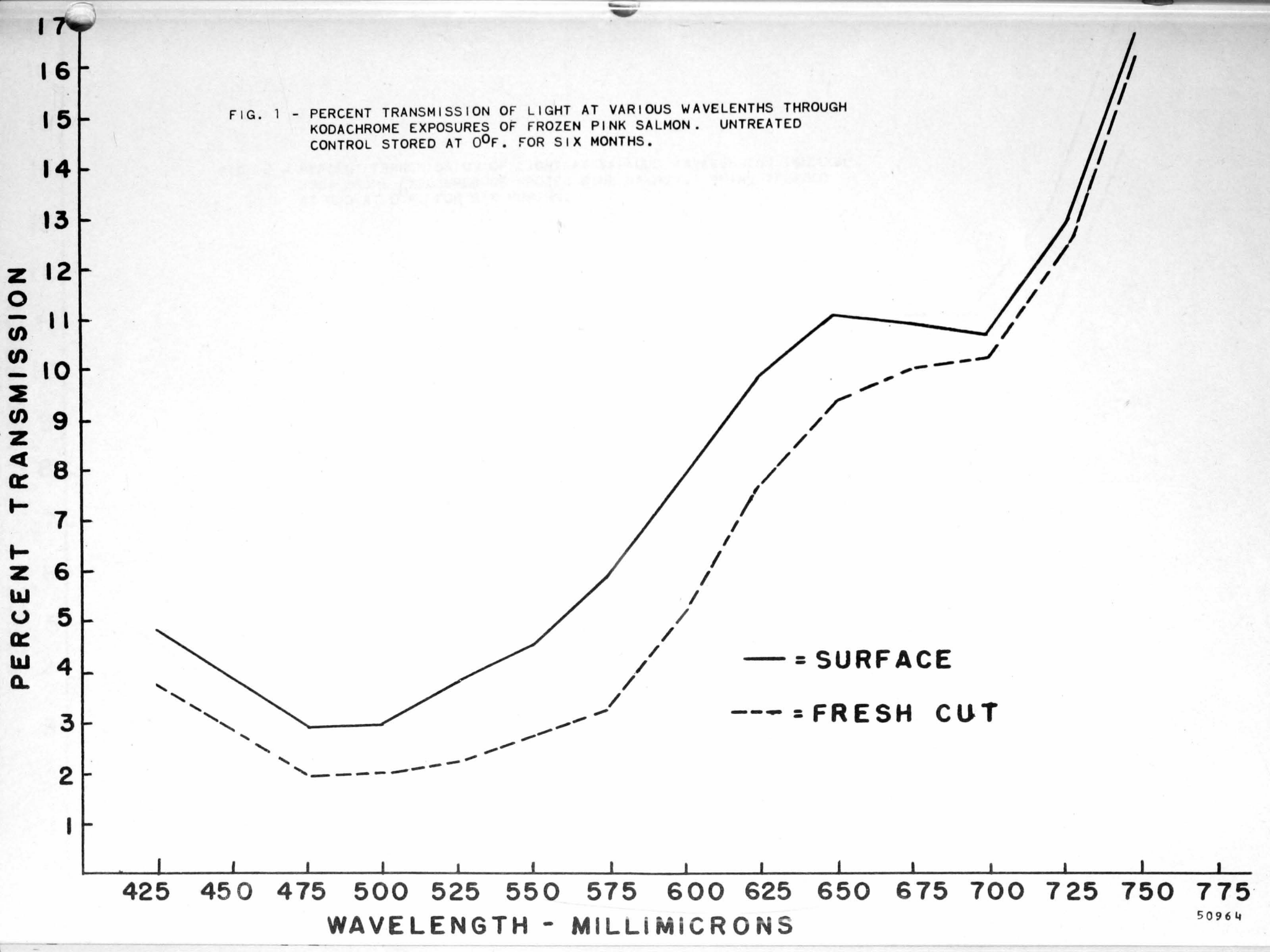

FIG. 2 - PERCENT TRANSMISSION OF LIGHT AT VARIOUS WAVELENGTHS THROUGH KODACHROME EXPOSURES OF FROZEN PINK SALMON. BRINE TREATED STORED AT 0°F. FOR SIX MONTHS.

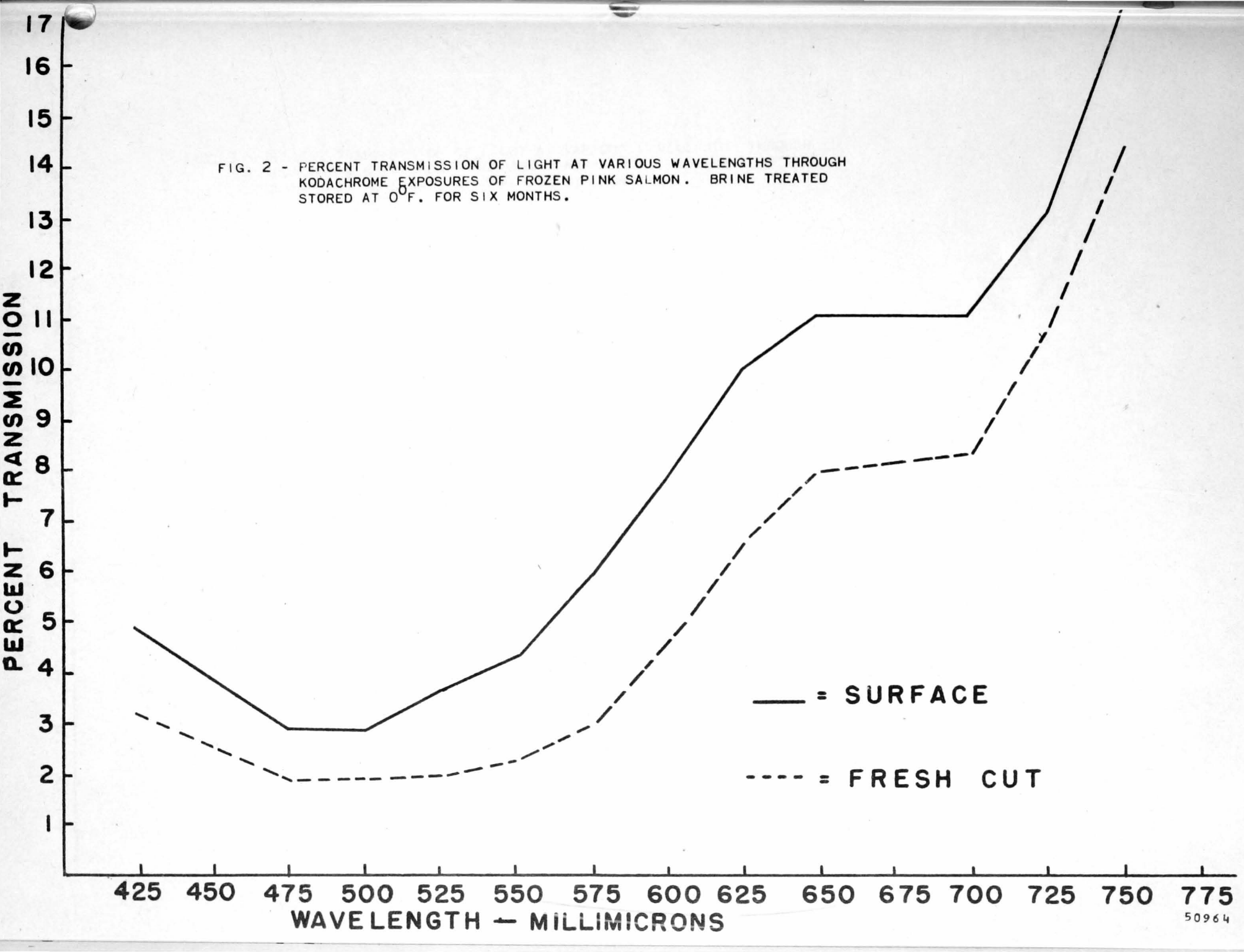

FIG. 3 - PERCENT TRANSMISSION OF LIGHT AT VARIOUS WAVELENGTHS THROUGH KODACHROME EXPOSURES OF FROZEN PINK SALMON. SODIUM NITRITE-BRINE TREATED STORED AT 0°F. FOR SIX MONTHS.