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THE EFFECT OF FLUORESCENT LIGHT
ON THE COLOR OF PICKLES

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Frank Lynn Baldwin
1952

This is to certify that the

thesis entitled

"Effect of Fluorescent Light on the
Color of Pickles"

presented by

Frank Lynn Baldwin

**has been accepted towards fulfillment
of the requirements for**

M. S. degree in Bacteriology & Public Health.

F. W. Fabian

Major professor

Date June 6, 1952

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THE EFFECT OF FLUORESCENT LIGHT
ON THE COLOR OF PICKLES

By

Frank Lynn Baldwin

A THESIS

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INTRODUCTION

The bleaching of pickles is an important problem in the pickle industry because it affects their salability. Bleaching may actually start in the field during the period of maturation and during harvesting. Bleached areas may appear on pickles where they come in contact with the soil. The bottom sides of the green cucumbers, where they come in contact with the ground, are always a lighter green than the top side which is exposed to the sunlight. In some instances areas on the bottom of cucumbers are bleached white. It is also very common to see bleached pickles floating around on top of uncovered salting tanks. Bleaching also occurs when salt stock is being removed from the salting tanks. Consequently many pickles are a few shades lighter than they should be if they are not properly handled. Furthermore, it has been shown by Fabian and Eisenstat (1) that during desalting and finishing certain procedures bleach the pickles. In the case of process dill pickles, certain manufacturing procedures will bleach the pickles almost white.

To prevent excessive bleaching during and after salting, tanks should be covered with a tarpaulin while filling and emptying them. This greatly reduces bleaching due to sunlight. Process dills should be freshened and the

finished pickles packed in the jars within 24 hours after they leave the tanks in which they were salted or after they are taken out of the salting brine.

Little attention has been given to the finished products by the packers after they are placed on the market. It has long been known that pickles in glass jars will bleach when placed in display windows for any length of time. However, it has not been generally known that bleaching will gradually take place in pickles in glass jars on the shelves of stores that are lighted with fluroescent light. This fact becomes all the more significant when it is appreciated that 99 percent of all stores today are lighted with fluorescent lamps.

It is to study the influence of fluorescent light on the color of pickles that this work was undertaken.

LITERATURE REVIEW

Considerable information has been published during the past few years on pickle and pickle products. However, the literature concerning the effect of fluorescent light on pickles is virtually non-existent.

Carpenter (2) found that the color, as well as the aroma and flavor of apple and kraut juices was definitely affected by light.

Mayer (3) stated that the gradual bleaching of carotene occurs as the crystals absorb oxygen from the air.

Strain (4) noted that strong oxidizing agents, such as zinc powder convert chlorophyll into labile, colorless products.

Taylor and Pracejus (5) using fluorescent lamps as a source of light for meat cases showed that processed meats were quite susceptible to color changes, whereas, fresh meats were not affected at an exposure of approximately 150-200 foot-candles-hours.

Ramsbottom, Goeser, and Shultz (6) found that frozen sliced processed meats were much more susceptible to discoloration than frozen sliced fresh meats. The fading of sliced processed meats was also accompanied by flavor deterioration.

Pivnick (7) found that bleaching started in the center

of the pickles and increased in extent until the whole pickle, inside and outside, was bleached.

Fabian and Eisenstat (1) showed that direct sunlight, infrared rays, and storage were important factors responsible for bleaching of pickles and to a lesser extent alum and vinegar.

EXPERIMENTAL PROCEDURE

Commercially sweet pickles, fresh pasteurized dills and processed dill pickles are whitened to the greatest extent. Of these the dill pickles are whitened with much greater frequency than sweets which by comparison are bleached only rarely.

In the experiments reported here six different lamps were used to determine the effect of fluorescent light on bleaching pickles. They were the soft white, the standard, the daylight, the warm white deluxe, the warm white and the standard cool white. All of these lamps were General Electric fluorescent, 40 watt, 4 ft. length regular size bulbs. They were mounted in the ordinary fluorescent lamp-holders and contained two 40 watt lamps to each holder. Under the lamps were placed tables, all of equal height allowing a distance of $5\frac{1}{2}$ feet between the top of the table and the lamps. By checking lamps in several super-markets it was found that $5\frac{1}{2}$ feet was the averagedistance of the fluorescent lamps from the pickle jars.

The illumination in foot-candles of each set of lamps was measured with a Weston foot-candle light meter. The intensities of each lamp varied from 4 to 18 foot-candles. The lamps were separated by double sheets of brown wrapping paper hung from the ceiling to the top of the tables. It is

believed that the conditions under which the experiments were done are fairly representative of those generally found in retail stores.

All pickles used in the experiments, with the exception of the fresh pasteurized dills, were obtained from the H. W. Madison Co. in Mason, Michigan. The fresh-pack dills were obtained from the Dailey Pickle and Canning Co., Saginaw, Michigan. The pickles obtained from the H. W. Madison Co. were in a brine of 60° salometer (16 percent salt). The sizes used ranged from 6,000 to 10,000. For all tests, pint Mason jars were used.

The pickles were carefully selected in order to get pickles of uniform size and green color. After removing them from the brine they were freshened in flowing water. The pickles were then tested for salt content by titrating with standard silver nitrate solution using dichloro-fluorescein as the indicator. The acidity was determined with 0.166 N NaOH using phenolphthalein as the indicator. All procedures for making the pickles were standardized so as to have a uniform product. In making processed dills the desalted pickles were weighed and the ingredients added in proportion to the weight so that they would all finish with the same amount of acid, salt and spices. The ingredients were standardized so that the pickles when finished tested 9 grains acid and 3.8 percent salt. Dill oil emulsion was added so that the final concentration of dill oil was 1:3000 in the brine and pickles.

The jars containing the pickles were then divided into 7 batches with 12 jars to each batch. The brine containing the acid, salt and spices was likewise divided into 7 lots and various ingredients added to each lot of brine to test the effect of the fluorescent light on the processed dills containing the various ingredients. The first lot of brine added to the first batch of pickles contained only the standard amount of acid, salt and spices. This will be called the "standard brine". This brine was added to the desalted pickles in batch No. 1 and was used as the control. The brine for the pickles in batch No. 2 contained, in addition to the standard amount of acid, salt and spices, 0.1 percent ammonium sulfate ($\text{Al}_2(\text{SO}_4)_3 \cdot 18 \text{H}_2\text{O}$). The brine for batch No. 3 contained the standard brine to which had been added soluble tumeric at the rate of 0.5 oz. per 100 gal. of the standard brine. It should also be noted that soluble tumeric had been added at the rate of 1.5 oz. per 100 gal. to the final freshening water used to freshen the pickles in this batch. Copper as cupric chloride at the rate of 15 and 25 p.p.m. respectively was added to the standard brine for the pickles in batches No's. 4 and 5. The standard brine for batch No. 6 contained a combination 0.1 percent alum and 0.5 oz. of soluble tumeric. The standard brine for batch No. 7 contained a combination of 0.1 percent alum, 0.5 oz. soluble tumeric and 15 p.p.m. of copper. Thus, the liquor and pickles in the 7 batches contained all the ingredients separately and

in combination that may be generally found in processed dills. The brines for the different batches of pickles were poured onto the pickles. The jars were then sealed and pasteurized at 165° F for 15 min. They were then allowed to stand for 48 hours until the liquor and pickles had equalized after which they were exposed to the various fluorescent lights.

Commercial fresh pasteurized dill pickles and three kinds of sweet pickles were also included in these experiments to test the influence of fluorescent light on them. The sweet pickles used were low-Baume sweet pickles testing 14.9° Baume (27° Brix), 12 grains acid and 2 percent salt; standard sweet pickles testing 20.35° Baume (37° Brix), 22 grains acid and 2 percent salt; and double or candied sweet pickles testing 25.7° Baume (47° Brix), 22 grains acid and 2 percent salt. The low-Baume sweet pickles were pasteurized at 165° F for 15 min. All pickles after being made were stored in a room protected from light until ready to use in the experiments.

Pint Mason jars, packed with each of the various types of pickles described were placed under each of the six lamps used in these tests. The jars were placed so that their sides rather than their tops were exposed directly to the lights. The top exposed sides were compared to the unexposed bottom sides. In addition, a set of unexposed pickles of each type was kept in the dark.

All lamps were turned on at the same time. The jars

of pickles were examined at 6-hour intervals for 134 hours.

The degree of bleaching was graded in the following manner:

- = no noticeable bleaching, 1+ = slightly bleached, 2+ = partially bleached, 3+ = highly bleached, and 4+ = completely bleached.

RESULTS

The data show that the standard cool white lamp caused bleaching in 12 hours as shown in Table 8. All lamps had shown definite evidence of bleaching at the end of 36 hours in the various types of pickles. In all the tests throughout these experiments (Tables 1 - 11), two lamps, the daylight and the standard cool white, consistently caused the earliest and greatest degree of bleaching. On the other hand the warm white deluxe lamp produced the least amount of bleaching at a relatively longer time of exposure than any of the other lamps.

Fresh pasteurized dills (Table 8) appeared to be the most susceptible group of pickles to bleaching by fluorescent light. This was evident by the complete bleaching of them by all lamps in 96 hours of exposure, except the warm white deluxe, which caused complete bleaching in 120 hours.

In the case of processed dill pickles the ones most susceptible to bleaching by fluorescent lamps in increasing order were those containing tumeric (Table 2); 0.1 percent alum (Table 3); 15 p.p.m. copper (Table 5); and 25 p.p.m. copper (Table 6). The general controls which contained only salt, acid and basic spices required a longer exposure time to bleach than did any of the processed dill pickles

to which the various ingredients had been added except the batch which contained the combination of 15 p.p.m. copper, 0.1 percent alum and tumeric, as shown in Table 7, which bleached even less than did the general controls. This indicates that this combination which is normally present in process dills serves to protect pickles against bleaching as well as adding color, crispness, and flavor to the pickles.

Sweet pickles when exposed to the different types of fluorescent lamps bleached in proportion to the concentration of sugar present (Tables 9 - 11). Pickles containing the lowest concentration of sugar (Table 9) bleached the most. The intensity of bleaching in low sugar concentrations was of about the same degree as that of the processed dills which showed the greatest bleaching.

It was noticed in all jars where severe bleaching occurred that the areas where the pickles were pressed tightly against the inner surface of the glass retained most of their original color. These areas, although tightly pressed against the jar, had trapped a thin film of brine between the jar and the pickles. Since the jars were laid on their sides, the brine fell away so that part of the pickles were not covered by the brine. These areas, which were not flush up against the jar invariably bleached. Where the brine covered the pickles which were not tightly pressed against the jar, bleaching also occurred. This interesting phenomenon prompted further experiments

in order to ascertain to what this protection against bleaching might be due.

Effect of Oxygen, Vacuum and Complete Coverage
with Brine on the Bleaching of Fresh Pasteurized
Dill Pickles by Fluroescent Light

In order to determine why pickles pressed against the sides of a jar did not bleach, pickles of uniform color were selected from a batch of commercially prepared fresh pasteurized dills and packed into 6 jars. Three of these jars were partially filled with brine so that parts of the pickles were not covered by the brine when the jars were laid on their sides and 3 were completely filled with brine. Then 4 of the 6 above jars, two completely and two partially covered with brine, were pasteurized at 165° F for 15 min. The remaining 2 jars were pasteurized at 165° F for 30 minutes in order to obtain a higher vacuum. Two of the low vacuum jars, one completely and one partially filled with brine, were cooled and then opened and oxygen bubbled through the brine of each jar of pickles for 3 minutes. All 6 jars were then exposed to the daylight fluorescent lamp. Observations were made every 12 hours for 96 hours.

As shown in Table 12, bleaching occurred in all 6 of these jars at the end of 24 hours of exposure irrespective of the treatments they received. However, where the pickles were pressed tightly against the jars, only very slight bleaching occurred.

The results definitely indicated that fluorescent light was responsible for the bleaching of pickles. The intensity of bleaching was proportional to the intensity of light, since the lamps with the highest foot-candles caused the greatest amount and most rapid bleaching. The ingredients of the brine had a slight bearing on the intensity of bleaching. A high concentration of sugar afforded some protection against bleaching. A combination of 15 p.p.m. copper, 0.1 percent alum and tumeric also gave slight protection against bleaching. Bleaching was slightly accelerated by 0.1 percent alum alone and tumeric alone.

The fresh pasteurized dill pickles appeared to be the most susceptible group to bleaching. Complete bleaching occurred most rapidly with these pickles.

The cause of the bleaching appears to be a strict photochemical process. Oxygen does not appear to assist this photochemical reaction. The light caused bleaching of the pickles regardless of the constituents in the brine and whether the pickles were completely or incompletely covered with brine. Only where the pickles were tightly pressed against the jar was there significant protection against bleaching. Although it was suspected that oxygen was present in those areas, oxygen cannot be implicated as an agent which can accelerate bleaching in the short space of time recorded in these experiments (Table 12). Oxygen

doubtless is a factor influencing color changes over a longer period of time and under different conditions. It is believed that the green areas in the pickles pressed tightly against the inner surface of the jar was due to the expulsion of air from the pickle cells and to the compression of the chloroplasts into a smaller area thereby intensifying the color.

SUMMARY

1. The various kinds of pickles studied were susceptible to bleaching when exposed to various types of fluorescent lamps for different periods of time.
2. The amount of bleaching was directly proportional to the intensity of the light.
3. Some of the ingredients of the brine afforded slight protection against bleaching while other ingredients had the opposite effect.
4. Bleaching by light appears to be a photochemical reaction.
5. Oxygen was not an important factor in the bleaching of pickles during the time intervals and under the conditions of these experiments.
6. The surface of the pickle which was pressed tightly against the inner surface of the jar was not bleached to the same extent as the rest of the exposed surface. The green color in these areas was probably due to the expulsion of the air from the pickle cells and to the compression of the chloroplasts.

TABLE 1

BLEACHING EFFECT OF FLUORESCENT LAMPS ON PROCESSED DILL PICKLES
CONTAINING 3.8 PERCENT SALT, 9 GRAINS ACID AND STANDARD SPICING

Kind of fluorescent light	Intensity (foot-candles)	Time in hours							
		0	12	24	36	48	72	96	120
Soft white	40	-	-	+	+	2+	2+	3+	4+
Standard	46	-	-	+	+	2+	3+	3+	4+
Daylight	50	-	-	+	2+	2+	3+	3+	4+
Warm white deluxe	36	-	-	+	+	2+	2+	3+	4+
Warm white	48	-	-	+	+	+	2+	3+	3+
Standard cool white	54	-	-	+	2+	2+	3+	3+	4+
Control	unexposed	-	-	-	-	-	-	-	-

In this and the tables which follow: - = no noticeable bleaching, + = slightly bleached, 2+ = partially bleached, 3+ = highly bleached, 4+ = completely bleached.

TABLE 12

THE EFFECT OF OXYGEN, VACUUM AND BRINE ON THE BLEACHING OF
FRESH PASTEURIZED DILL PICKLES BY THE DAYLIGHT LAMP

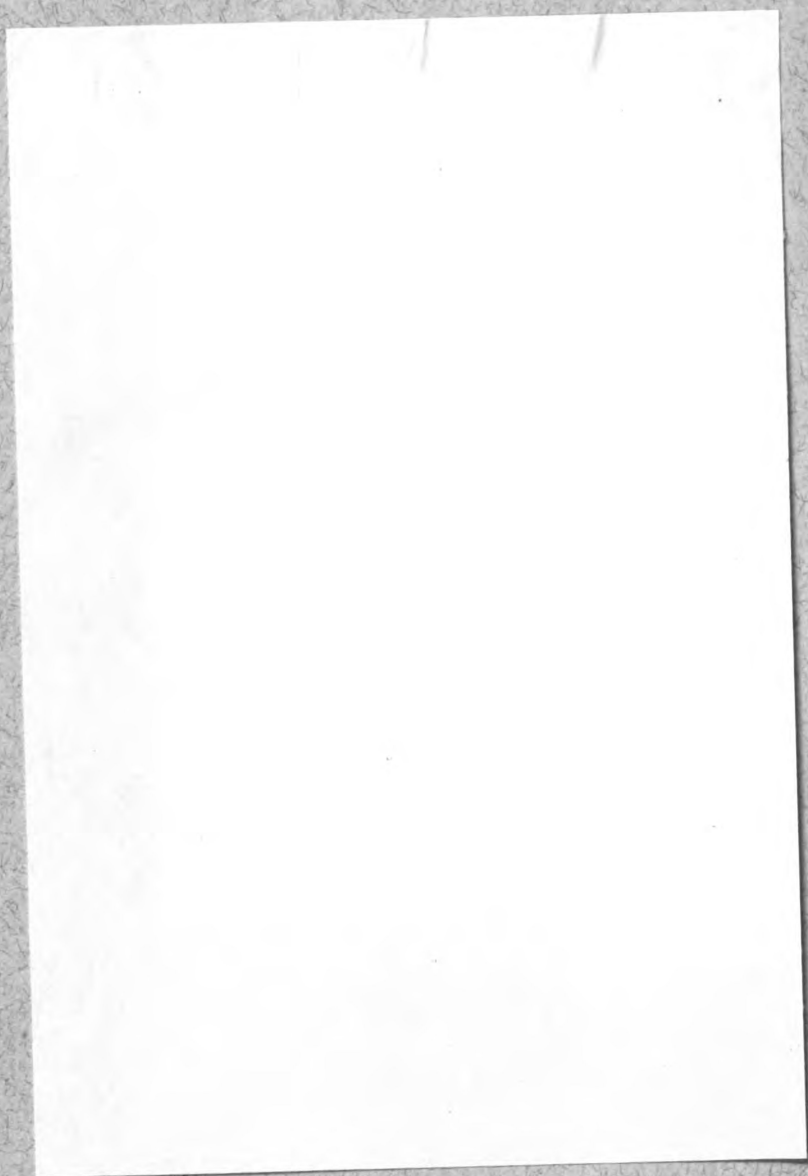
Treatment	Intensity (foot-candles)	Time in hours							
		0	12	24	36	48	72	96	
Pickles completely covered with brine.									
Brine saturated 3 minutes with oxygen.	50	-	-	+	2+	2+	3+	4+	
Pickles not completely covered with brine.									
Brine saturated 3 minutes with oxygen.	50	-	-	+	+	2+	2+	3+	
Pickles completely covered with brine.									
14" vacuum	50	-	-	+	+	2+	3+	3+	
Pickles not completely covered with brine.									
12" vacuum	50	-	-	+	+	2+	2+	3+	
Pickles completely covered with brine.									
Packed in normal manner.	50	-	-	+	2+	2+	3+	4+	
Pickles not completely covered with brine.									
Packed in normal manner.	50	-	-	+	+	2+	3+	4+	
Control	unexposed	-	-	-	-	-	-	-	

Slide I. Bleaching of pickles (degree)

Slide II. Pickle tightly pressed against jar
exhibiting protective action

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