THE CHEMICAL AND PHYSICAL FACTORS PRODUCING GREEN COLOR IN PICKLES

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THE CHEMICAL AND PHYSICAL FACTORS PRODUCING GREEN COLOR IN PICKLES

by

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INTRODUCTION

The color of commercially packed pickle products is subject to wide variation. Not only is there varietal difference in color, but also in the same variety of pickle put up by the same packer. Color is important in the sales appeal of pickles packed in glass since a good color attracts a potential customer to the product. Color also may be an index to the quality of the product. A product that shows bleached areas or varies a great deal in color usually indicates a low quality product. Therefore, care should be taken in color grading of the product. Some factors that affect the color of pickles are uncontrollable such as climatic and soil conditions.

The packaging of pickles in an acid medium helps to destroy the green color by conversion of the chlorophyll to pheophytin. This cannot be helped because the acetic acid is essential in the flavor as well as in the keeping quality of the product. It was the purpose of this work to study all of the factors that are involved in pickle manufacture, which would affect the green color of the finished product and, if possible, to restore the green color either wholly or in part by chemical or physical treatments.

LITERATURE REVIEW

The preservation of the green color of pickles is a problem of the relative stability of the chlorophyll molecule. Willstater in 1913 (1) states that the retention of the magnesium metal in the chlorophyll molecule is correlated with greenness. This metal is readily replaced with hydrogen ions contained in dilute acid solutions. The resulting magnesium-free compound is called pheophytin which is responsible for the olive green color.

Blair and Aynes (2) state that the first attempt to protect the greenness in canned vegetables was done by Blassneck in 1910. This was done by blanching the vegetables in an alkaline solution before canning. These authors also outline the process that is now used to can peas to preserve the natural green color. This process consists of (a) a preheat treatment by immersion of the peas at room temperatures in a 2-percent sodium carbonate solution, (b) blanching in a 0.005 molar calcium hydroxide solution, (c) canning in a salt-sugar brine to which is added a 0.020 to 0.025-percent suspension of magnesium hydroxide.

Eisenstat (3) studied the destruction of color in pickles by light. He found that light in the infrared range was the most effective in producing bleaching.

Jones (4) stated that sodium benzoate was capable of producing a green color in pickles. Jones also stated (5) that steaming of the pickles in certain spice oil vapors

produced greenness in pickles. He was of the opinion that this greenness was not due to changes in the chlorophyll, but to the production of a new color compound.

Magnus, Mabee, and Reynard (6) give several formulas for using the certified food dyes in the coloring of pickles.

EXPERIMENTAL METHODS

Commercial practices were followed in these experiments as closely as possible. In all cases, unless otherwise indicated, the pickles were packed in 1-pint Mason jars. One hundred grams of pickles were added to each jar and 400 ml of finishing liquor added. The pickles used were cured salt stock obtained from the Michigan Pickle Company, Lakeview, Michigan. The pickles were desalted before use by freshening in running lukewarm tap water for 24 hours followed by soaking for 4 hours each in 4 changes of distilled water. The pickles were divided into 2 batches and 1 batch was made into standard sweet pickles by the usual dry sugar method and when finished tested 37-percent sucrose, 2-percent acid as acetic, and 2-percent salt. The other batch was made into processed dill pickles by the addition of a brine consisting of the proper amounts of salt and vinegar so that the finished product tested 0.8-percent acid and 2-percent salt. In the latter case pasteurization was accomplished by immersion of the closed jars in a hot water bath

until an internal jar temperature of 165°F had been reached and held 15 minutes at this temperature. The jars were cooled immediately.

All salt and acid determinations were made by titration. In the case of salt, 0.1711 N silver nitrate was used with dichlorofluorescein as an indicator. The acid titrations were carried out using 0.1666 N sodium hydroxide with phenolphthalein as the indicator. Sugar concentrations were measured by an Abbe refractometer.

The pickles used were the 6000 size and were carefully inspected before use. They were all of essentially the same color with no bleached areas nor physical defects.

THE EFFECT OF METALS

To determine the effect of various chemicals on the greening of different kinds of pickles, metals were given first consideration since it is well known that the salts of copper cause a green color to develop in the pickle. The metals were first screened to decide which ones might come in contact with the pickles at any time during their manufacture. Some metals such as bismuth were not used because of the relative insolubility of their salts. Others such as gallium, cerium, etc., were considered to be of too rare occurrence to be commonly found in the manufacturing operations.

Various salts of the metals were used to prepare a stock solution of each metal so that the concentration of the metallic ion was present in a 1:1000 dilution of metal to water. Chloride salts were used wherever possible. However, when these were not available or relatively insoluble other salts such as sulfates were used. The metallic salts were first dried in an electric oven at 100°C ± 2°C for 24 hours, after which they were weighed and placed in a liter volumetric flask and filled to the mark with distilled water. The amount of metallic salt used to obtain the desired concentrations of metal are given in table 1. This stock solution was then used to prepare 3 different solutions containing 1, 10, or 100 ppm of the metallic salt, which were the concentrations used in these experiments. Proper amounts of C.P. sodium chloride were added to each of these solutions to make a final concentration of 2-percent sodium chloride. Each solution of the metallic salt was then divided into 4 equal lots. The first was untreated. The second lot was acidified with glacial acetic acid to 0.8-percent. The third lot was acidified to 2-percent with glacial acetic acid. The fourth lot in addition to acidification to 2-percent contained enough sucrose so that the final sugar concentration was 37-percent.

Prior to the addition of the above solutions, the freshened and desalted pickles were also divided into 4 lots and treated as follows: Lot 1 was untreated; lot 2 was acidified with glacial acetic acid to 0.8-percent acid and

Table 1

Lists of Metallic Salts Used to Treat Pickles

Metal	Molecular Weight of Metal	Chemical Formula of Salt Used	Molecular Weight of Salt	Grams of Salt Used to Give 1:1000
Aluminum	26.97	$AlCl_3$	133.34	4.944
Antimony	121.76	$SbCl_3$	228.13	1.873
Barium	137.36	$BaCl_2$	208.72	1.519
Beryllium	9.01	$BeCl_2$	79.93	8.871
Cadmium	112.41	$CdCl_2$	183.32	1.630
Calcium	40.08	$CaCl_2$	110.99	2.769
Cerium	140.13	$CeCl_3$	246.5	1.759
Chromium	52.01	$CrCl_2$	122.92	2.363
Cobalt	58.94	$CoSO_4$	155.00	2.629
Copper	63.57	$CuCl_2$	134.48	2.115
Iron	55.84	$FeCl_3 \cdot 6H_2O$	270.31	4.840
Lead	207.21	$PbCl_2$	278.12	1.342
Lithium	6.94	LiCl	42.40	6.109
Magnesium	24.32	$MgCl_2$	95.23	3.915
Manganese	54.93	$MnCl_2$	125.84	2.290
Mercury	200.61	$HgCl_2$	271.52	1.353
Nickel	58.69	$NiCl_2$	129.60	2.208
Potassium	39.10	KCl	74.55	1.906
Silver	107.88	$AgNO_3$	169.89	1.574
Strontium	87.6	$SrCl_2$	158.54	1.809
Thallium	204.39	TlCl	239.85	1.173
Tin	118.70	$SnSO_4$	214.76	1.809
Zinc	65.38	$ZnCl_2$	136.29	2.084

sufficient NaCl added to give a final concentration of 2-percent; and lots 3 and 4 were acidified with glacial acetic acid to 2-percent acid and sufficient NaCl added to give a final concentration of 2-percent. In addition the fourth lot had been sweetened with sucrose so that the sugar concentration was 37-percent. The above treatment of the 4 lots of pickles was necessary so that they would have the same acid and salt content as the liquors which were then added to them.

The pickles were placed in pint Mason jars and the respective liquors poured over them. These liquors had the same acid and salt content as the pickles and also contained the various metallic salts shown in table 1 in concentrations of 1, 10, and 100 ppm. Proper controls were prepared for comparison which contained no metallic salts. The jars were then closed and heated in a hot water bath until they reached an internal temperature of 180°F and were then held at this temperature for 15 minutes. The jars were immediately cooled and stored in their original cases. In these experiments there was a total of 276 jars treated with the various metals and 24 control jars. Observations were made at the end of 1 day, 2 weeks, 1 month, and 5 months.

Results

At the end of 5 months the pickles were removed from the jars and placed beside a control for comparison. The pickles to which the metallic salts had been added in con-

centrations of 1, 10, and 100 ppm showed no change in color except those treated with the copper salt, which at the end of one week gave the results indicated in table 2, and showed no further changes throughout the course of the experiments.

Table 2

Amount of Copper Chloride Required to Produce Green Color in Pickles

Concentration of Copper in ppm	Composition of Liquors in Percent					
	NaCl 2	NaCl 2 HAc 0.2	NaCl 2	HAc 2	NaCl 2	HAc 2 Moisture 77
0	-	-	-		-	
1	+	-	-		-	
10	+	+	+		+	
100	+	+	+		+	

+ = Green Color - = No Green Color

Discussion of Results

Copper was the only metal of those listed in table 1 that gave any color change in the pickles in the dilutions used. In a non-acid solution 1 ppm copper was sufficient to give a green color to the pickles. It was later found that in an acid solution at least 3 ppm of copper chloride was needed to produce a green color in pickles.

THE INFLUENCE OF SODIUM BENZOATE

Pickles which had been freshened as previously described were added to pint Mason jars. To 10 sets of jars in duplicate were added solutions containing from 1 to 10-percent sodium benzoate at 1-percent increments. To one set of the duplicates of each increment, glacial acetic acid was added to give a final concentration of 1-percent acid. A white precipitate formed in the acidified solutions, which doubtless was insoluble benzoic acid. The 20 jars were closed and stored for 3 months.

Results

Observations made at time intervals of 1 week, 1 month, and 3 months showed that a green color appeared in the pickles at the end of 1 week in the concentrations indicated in the accompanying tabulation and did not increase in intensity thereafter.

Table 3

Amount of Sodium Benzoate Required to Green Pickles

Solution	Percent of Sodium Benzoate									
	1	2	3	4	5	6	7	8	9	10
Distilled water	-	-	-	-	+	+	+	+	+	+
1-percent acetic acid	-	-	-	+	+	+	+	+	+	+

\+ = Green Color - = No Green Color

Discussion of Results

In distilled water sodium benzoate produced a green color in pickles within a week in the 5-percent concentration. The green color produced was a deeper and more intense green than was produced in an acid solution. In the solution which was acidified to 1-percent with glacial acetic acid, the green color was produced at a 4-percent concentration of sodium benzoate. However, the green color produced was not as intense a green as that produced in the pickles when they were treated with different percentages of sodium benzoate dissolved in distilled water. The precipitate which formed in a 1-percent acetic acid solution was tested according to the official preliminary and also the ferric chloride quantitative tests of A.O.A.C., p. 455 (7), which showed the white ppt. to be benzoic acid. This would indicate that the sodium benzoate in the 1-percent acetic acid solution formed benzoic acid and sodium acetate. Since benzoic acid in water is soluble to the extent of only 0.27 grams per 100 ml. of water at 18°C, the excess remained as the insoluble precipitate.

Additional experiments seemed to verify Jones' statement (4) that the green color produced was a new color compound and not due to the chlorophyll. The greened pickles were washed in running lukewarm tap water overnight, soaked in distilled water 12 hours, and then placed in an acid medium. These pickles were then placed in the direct sunlight

for several days. They held their color much better than ordinary pickles did under the same conditions.

THE EFFECT OF SPICE OILS

The effect of spice oils on the color of pickles was first studied by using a 21-percent emulsion of the following oils: Cloves, ginger, celery seed, nutmeg, mace, orange, lemon, cassia, coriander, cardamon, mustard, pimento (allspice), garlic, black pepper, and dill. The normal concentration of spice oils used for spicing pickles is usually about 1:3000, that is, 1 part spice oils to 3000 parts of pickles and liquor. However, to speed up the reactions a 1:1000 concentration was used in all spicing reported here.

Processed dill pickles were used to test the influence of spice oils alone and in combination on the color of dill pickles. The spice oils tested for the dill pickle experiments were: dill, garlic, mustard, black pepper, and a combination of these in a commercial spice oil formula. The spiced dill brine used was divided into two portions. One portion was first heated, as is sometimes done in commercial practice, before it was poured over the pickles in the jars; while the other portion was poured over the jars cold, the jars sealed, and then placed in a hot water bath and pasteurized at an internal jar temperature of 165°F for 15 minutes. In both experiments the jars were cooled immediately and stored for 1 month.

Standard sweet pickles were tested by adding hot and cold sweet spiced liquor containing the various spices previously listed, as well as combinations of these oils as found in several commercial formulas. Controls for these experiments consisted of pickles from the same lot treated with unspiced brine and sweet liquor.

Results

The controls, processed dills and sweet pickles, were stored at room temperature for one month after which they were examined for any color changes. A comparison of the processed dills and sweet pickles with the controls at the end of 30 days showed only two instances of color change. A deeper green color was noted in the jars of sweet pickles to which the sweet liquor containing oil of pimento had been added, but no change in color was observed in the pickles to which the cold sweet liquor containing oil of pimento had been added. The other change was noted in the case of garlic oil which caused bleaching of the standard sweet pickles in the case where sweet liquor containing garlic oil in a 1:1000 concentration had been used. No bleaching was observed in standard sweet pickles treated with cold sweet liquor containing this same concentration of garlic oil nor in processed dill pickles treated in the two ways as previously described.

Discussion of Results

It was concluded from this that heat was necessary to produce a noticeable color change within a 30 day period. To confirm the above results additional experiments were set up as follows: Standard sweet pickles were cut in half and one half of the pickle was suspended over a beaker containing 5 ml of each of the spice oils previously listed. The beaker was then heated for 30 minutes under a hood during which time the pickle was subjected to the hot oil vapor given off by the oils. With this drastic treatment oil of pimento was the only spice oil which produced any color change when compared to the other half of the standard sweet pickle not subjected to this treatment which was used as a control in comparing color changes. From these results it was concluded that of all the spice oils tested, oil of pimento was the only one which produced any noticeable color change in standard sweet pickles. This change was not believed due to the heat to which the half of the pickle was subjected, since no difference in color could be noticed when other spice oils were used. To further check this, other pickles from the same lot were cut in half and one half was subjected to steam for 30 minutes and the other half left unheated as a control. No color change was noted in the heated half of the pickle.

The only other conclusion which can be deduced from these experiments is that garlic oil causes bleaching in 30 days time only in the presence of hot sweet liquor. This

does not preclude the possibility that garlic oil cannot cause bleaching in either standard sweet pickles nor in processed dill pickles in a longer length of time nor under different circumstances. The interesting thing is that there is present in garlic oil a principle which under certain conditions can cause bleaching of the color from pickles. This was true of no other spice oil tested.

THE EFFECT OF DIFFERENT SUGARS

To determine the influence of sugars on the color of pickles, 3 different sugars were used as sweetening agents, viz., d-glucose, d-fructose, and sucrose. Standard sweet pickles were prepared by the commonly used dry sugar method using these 3 sugars. When the sweetening process was completed, the pickles sweetened with each sugar were divided into 4 lots. The first lot sweetened with each sugar was left untreated. The second lot was treated as follows: The sweet liquor was poured off the pickles and heated to the boiling point, poured back over the pickles immediately, and the pickles and liquor cooled at once.

The third lot was treated the same as lot No. 1, except that a 1:3000 concentration of spice oils was added to the respective sweet liquors. The composition of the spicing mixture was 60 parts oil of cloves, 20 parts oil of cassia, and 20 parts oil of pimento. The fourth lot was the same as

lot No. 2, except that the same spice mixture as in lot No. 3 was added in a 1:3000 concentration.

As controls for the 4 lots of pickles sweetened with three different sugars, another set of 4 lots of pickles was prepared which contained the same amount of salt and acid, but no sugar. These were given the same treatment as regards heat and spices as just described for the 4 lots of sweetened pickles. This made a total of 16 different lots of pickles, 12 sweetened and 4 unsweetened, for this series of experiments. All jars of pickles in the 16 lots before any observations were made for color changes were stored for 30 days.

Results

From the standpoint of color all pickles that had been treated with any of the three different sugars showed a deeper green color than the unsweetened samples at the end of 30 days. No color differences could be discerned between the pickles sweetened with the three sugars. This was true irrespective of the heat and spice treatments which they received. It must be concluded from these results that sugar does change pickles to a deeper green color in the presence or absence of heat or spices.

THE EFFECT OF BLANCHING

Blanching has been used in the canning industry for a great many years. One of the several reasons for blanching is to set the color in the vegetable. Pickles as made today do not go through a process of blanching. Therefore, experiments were done to see whether blanching would have any effect on the color of finished pickles. Fresh cucumbers of the long green produce variety were used, since the pickling variety was not available at this time of year. Four different blanching procedures were used, viz., boiling water, steam, boiling 0.005 M calcium hydroxide solution, and a boiling 0.005 M calcium hydroxide solution preceeded by a 2 hour immersion in a 2-percent sodium carbonate solution at room temperature. The time intervals used were 1 to 5 minutes at 1 minute intervals, followed by immediate cooling in cold water. The pickles were sliced into 1/4 inch slices, one slice of each of 6 pickles or a total of 6 slices were blanched according to the procedure just outlined. Controls were unblanched slices from the same pickles. Four separate lots of pickle slices were prepared. Each of the lots consisted of separate batches of pickle slices that were treated at the various time intervals indicated above in the 4 blanching procedures together with the proper controls. The first of the 4 lots was immersed in a cold 7.9-percent salt brine for 2 hours immediately after the blanching process. The second lot, immediately after the blanching process, was

immersed in a 7.9-percent brine solution which was kept at a temperature of 120°F for 30 minutes. The third and fourth lots were the same as the first and second respectively except that the immersion of the pickle slices in the brine solution preceded the blanching process. The slices were then made into fresh pasteurized dill slices by placing in hot jars and covering with a finishing brine consisting of the proper amounts of vinegar, salt, and spice emulsion. The closed jars were then pasteurized at 165°F for 15 minutes. They were cooled immediately by immersion in cold water. A total of 80 jars of blanched pickle slices were prepared along with 8 control jars of unblanched pickles. The slices tested when finished 0.69-percent acid and 2.1-percent salt.

Results

Observations were made one day after the pickles were made and pasteurized. The pickle slices were removed from the jars and placed beside each other in glass trays for comparison. The pickle slices that received any of the 4 different blanching treatments previously described had a much better retention of green color than those that received no blanching treatment. There was no great difference in color retention whether the blanching treatment preceded or followed the immersion in the salt brine or whether the pickle slices were treated in a hot or cold brine. There was no great difference in the texture of the pickle slices

treated by any of the above methods. The conclusion that may be drawn from these experiments is that any of the above blanching methods helps in the green color retention of pickles.

METHODS USED TO COLOR PICKLES

Chlorophyllin

It has long been known that the greenness of vegetables is destroyed by an acid medium and exposure to light which completely destroys the chlorophyll. Therefore, attempts were made to color pickles with water soluble chlorophyll products. Two types of water soluble chlorophylls were used in this experiment. They were potassium magnesium chlorophyllin and sodium potassium copper chlorophyllin. Since these compounds were insoluble in an acid medium, freshened salt stock pickles were placed in distilled water which had been adjusted with sodium hydroxide to a pH of 7.5. One ml of each of the chlorophyllins was added to duplicate 32 ounce jars of pickles and liquor, the ratio of pickles to liquor being 2 to 1. Observations after 1 week's time showed the pickles were definitely colored with the chlorophyllins. However, there was no uniformity of color; the worts on the pickle were almost black in color. Attempts to remove this dark color from parts of the pickle and obtain a uniform colored product were unsuccessful. The

pickles still retained uneven color after they were made into processed dills.

Certified Food Dyes

A stock solution of each of the dyes used was prepared by dissolving 1 ounce of the powdered dye in 1 pint of hot distilled water. These stock solutions were blended in various ways and the blends used in this experiment to color pickles. Coloring was done by adding 1 ml of the blends to 16 ounces of pickles and liquor. The ratio of pickles to liquor was 2 parts pickles to 1 part liquor. The following blends have been found to color pickles satisfactorily.

		Blend A	Blend B
Yellow #5	Tartrazine	50 parts	46 parts
Blue #2	Indigo Carmine	35 parts	29 parts
Orange #1	Orange I	15 parts	25 parts

Blend A produced a green color in the pickles typical of the color found in sweet pickles. However, blend A did not give a uniform color if there was a great variation in the color of the pickle before dyeing. If the pickle was not of uniform color due to chlorosis, a disease such as mosaic, or where it had come in contact with the ground, the color added by this dye did not overcome the color difference. The lighter colored portion of the pickle was still much lighter than the darker portion. Blend B produced a much darker color and was much better suited than blend A in coloring pickles that had bleached areas. The best results

were obtained with blend B when the color in the pickles was fixed during the presouring process by heating the colored pickles in 0.2-percent aluminum sulfate ($Al_2(SO_4)_3 \cdot 18H_2O$) solution for 5 minutes at 165°F. When this was done, the sweet liquor on the pickles was only slightly colored at the end of 5 months storage time, indicating a good retention of the dye in the pickle.

DISCUSSION

A study of the color changes in pickles presents many difficulties. There are many variables to be considered which may have a definite influence on the final color of the product. The greatest care possible was used to keep the number of variables at a minimum throughout these experiments so that each of them could be studied by itself.

It has long been known in the pickles industry that the salts of copper will cause a greenness in pickles. This was confirmed since it was the only metal studied in these experiments that would bring about this reaction.

Spice oils may have a definite effect on color, especially when long storage life is a factor. In a thirty day storage period oil of pimento was shown to cause a definite greening action on the pickles. The concentration used here, however, was 15 times greater than that which would be used ordinarily. Garlic oil was shown to have just the opposite action, since it caused bleaching. However,

the concentration of garlic oil in sweet pickles is very small and the amount used here was probably more than 100 times greater than the concentration ordinarily used.

The three sugars used in these experiments all produced a darkening of the green pigment of the pickles. No difference could be noted in the depth of color caused by the three different sugars. This would indicate that the chemical structure of the sugar per se was not responsible for the change since d-glucose is an aldehyde sugar, d-fructose is a ketone sugar, and sucrose is a disaccharide in which the d-glucose and d-fructose are combined and which has no free reducing group. The color change must, therefore, be due to some other action of the sugars on the pickle.

Sodium benzoate caused a definite greening in the pickles when used in concentrations greater than those allowed by law. In a neutral solution there was no greening noted in concentrations up to 5-percent. However, in an acid solution beginning at 4-percent a definite green color was produced. This color remained and was stable when the pickles were washed in running warm tap water overnight; soaked in distilled water for 12 hours; and packed in an acid medium. Furthermore, the color did not fade when the pickles were subjected to direct sunlight for a week. This would indicate that the color formed was very stable and may, as Jones (4) suggests, be a new color compound.

Blanching, as done in these experiments, had a definite preserving action on the green color of pickles. The

cucumbers used here were not of the pickling variety, since they were out of season at the time of these experiments. Crispness and storage life must be considered in connection with blanching. In these experiments these factors were not given sufficient consideration since the observations were made immediately after pasteurizing. However, none of the pickle slices were soft because of the blanching and pasteurizing treatments which they received; so it is believed that the storage life and crispness would not be seriously impaired by blanching. In fact, with the thick skin produce variety of cucumber, blanching would actually improve the edibility since it would tenderize the skin. It has been found, since heat treatment has become more general in pickle manufacture, that cucumbers will withstand a great deal more heat than formerly was believed when the old methods of making pickles were used.

These experiments have also demonstrated that certain combinations of certified food colors may be used in producing a satisfactory green color in pickles under the conditions employed here. Certain combinations were much better than others in this respect. By increasing or decreasing the amount of yellow or blue, different shades of green may be produced. Attempts to color pickles with two water soluble chlorophyll products, viz., potassium magnesium chlorophyllin and sodium potassium copper chlorophyllin, were unsuccessful. The pickles were colored; but it was impossible

under the conditions used to obtain a uniformly colored product.

SUMMARY

Under the conditions of these experiments:

1. Copper was the only metal tested which produced a greenness in pickles. It produced a greenness in pickles in a concentration of 1 ppm in a neutral solution and 3ppm in an acid solution.
2. Sodium benzoate produced a greenness in pickles in a concentration of 5-percent in a neutral solution and of 4-percent in an acid solution.
3. Oil of pimento produced a greenness in standard sweet pickles in a concentration of 1:1000 in heated sweet liquor. Oil of garlic was found to cause a loss in green color of pickles under the same conditions.
4. D-glucose, d-fructose, and sucrose all produced a darkening of the color of pickles when used to sweeten pickles. No color differences could be discerned between pickles sweetened with the 3 sugars, irrespective of the heat and spice treatments which they received.
5. Blanching of pickles had a definite preserving action on the green color of pickles.

6. Attempts to color pickles with 2 water soluble chlorophyll products, viz., potassium magnesium chlorophyllin and sodium potassium copper chlorophyllin were unsuccessful. These compounds would readily color the pickles in a basic but not in an acid medium. A uniformly colored product was not obtained in the basic solution.
7. Certain combinations of certified food colors were used in producing a satisfactory green color in pickles. Different shades of green color in pickles could be obtained by increasing or decreasing the proportions of the constituents of the dye.

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