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Nature, Causes and Correction of Discoloration of Canned Blackeye and Purple Hull Peas

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DIGEST

Properly canned blackeye or purple hull peas are a favorite food with many people in the Southern States. However, due to a brown or black liquor discoloration, the canned product has met with some sales resistance.

Most of the discoloration is caused by the anthocyanin pigment of the seed coat.

The discoloration can be controlled by the use of 3 percent ammonium alum or aluminum sulfate as a blanching solution, or by the use of a high-temperature and short-time sterilization process, or by combining these two methods.

Unless pressurized cooling facilities are available, the use of a high-temperature and short-time process is not recommended.

A desirable side-effect derived from the use of aluminum salts in the blanch solution is the reduction of both the viscosity of the liquor and gelling in the can.

Though ammonium alum is used extensively in the manufacture of pickles from cucumbers and also is used as an aid in purifying drinking water, any one anticipating the use of ammonium alum or aluminum sulfate to control discoloration should first clear the process with the U. S. Food and Drug Administration.

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Nature, Causes and Correction of Discoloration of Canned Blackeye and Purple Hull Peas

W. H. Culver and R. F. Cain*

BLACKEYE PEAS can be grown in nearly all parts of Texas. The area generally spoken of as "East Texas" is especially well adapted to the growing of this crop and a number of canneries are located in that part of the State. Large acreages of blackeyes are grown and packed in the Lower Rio Grande Valley. Some peas also are produced in the vicinity of Lubbock.

The blackeye pea canning industry is centered mainly in Texas. Seventy-nine percent of all blackeyes canned in the United States in 1949 were packed in this State. Approximately 1,500,000 cases of blackeye and purple hull peas were packed in Texas during 1948. (10,11)

In spite of the desirable characteristics of blackeye and purple hull peas, the canning of these products has not expanded as much as normally would be expected. The three main reasons for this are: uneven maturation of the pods, which makes mechanical harvesting impractical; the tendency of canned peas to have a viscous liquor that sometimes forms a gel; and the very dark, undesirable appearance of most canned blackeye and purple hull peas. This bulletin is concerned with the last named characteristic of the peas.

Brown or black discoloration of peas is undesirable from several standpoints. Of primary concern is the fact that the consumer not familiar with Southern peas (edible varieties of the cowpea, **Vigna sinensis**), is likely to consider the badly discolored product as spoiled and discard it. Home economists long have recognized the fact that eye appeal is very important. It is sometimes the factor which determines whether the product is accepted or rejected. Discolored peas certainly lack eye appeal. The darkening of the canned peas masks the green color of the fresh green-shelled product. On the basis

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of color alone, canned green peas frequently are indistinguishable from canned dry peas.

Presence of discolored peas in the can is also undesirable from the standpoint of U. S. grade.

Typical examples of commercially canned peas have a very viscous dark liquor and the peas themselves may be discolored so badly that the discoloration extends through the cotyledon.

REVIEW OF LITERATURE

Only brief mention has been made in the literature of discoloration in canned Southern peas. Sherman (24) observed that the severity of darkening was proportional to the amount of seed-coat coloration.

Cain and Brittingham (4) reported that blackeye and purple hull peas canned in plain tin were subject to more severe discoloration than were those canned in "C" or "R" enamel cans. The C enamel was slightly more desirable. Cream peas were not influenced as greatly by the container coating. The darkening of pigmented seedcoats, which can be decreased through the use of the proper container, is secondary to the more severe darkening of the product.

The literature revealed that morphology and pigmentation of the seedcoat of Southern peas are associated with the discoloration of the canned product. Therefore, a portion of this review is devoted to the work of Albert Mann on the seedcoat of cowpeas.

Mann (17) published a treatise on the morphology and pigmentation of the seedcoat of cowpeas. The seedcoat is composed of three distinct layers of cells, the outer palisade layer, the middle "hour glass" layer and the inner "basal-color" layer. He stated that there are two types of pigment in the seedcoat of cowpeas. They are anthocyanins and a melanin-like compound. The anthocyanin is responsible for the dark colors in the seedcoat. It occurs only in the palisade layer and sometimes only in some of the cells of that layer. In blackeye peas, it occurs only in the cells immediately around the hilum. The melanin-like substance occurs mostly in the basal-color layer but sometimes is found in the palisade cells.

The anthocyanin in cowpeas consists of two phases or types. One is an acid-reacting anthocyanin, ranging in color from a decided rose red to a strong purple. The other, an alkaline-reacting anthocyanin, is uniformly a deep indigo blue but in mass it often appears dead black.

Gortner (5) found that the melanin in sheep's wool is insoluble in neutral or acidic solutions, but that it is soluble in alkalies; therefore, it is concluded that, at the pH normally encountered in canned blackeye and purple hull peas, the melanin-like substance probably is insoluble and is not an important factor in discoloration.

Many excellent reviews have been published on the properties and chemistry of anthocyanins (13, 14, 15, 21, 22, 23, 25). A complete discussion of properties and nature of these plant pigments is beyond the scope of this report. However, it is pertinent to point out that anthocyanins are the glucosides of anthocyanidins, according to Bancroft and Ratzler (1). They found that anthocyanins can be prepared by the reduction of the corresponding flavinols or the oxidation of leuco-anthocyanins. *In vitro* this can be accomplished only with strong reagents, although these reactions probably proceed *in vivo* with the assistance of enzymes.

Leuco-anthocyanins are almost always found in plant tissues where anthocyanins are present (16).

PROCEDURE, RESULTS AND DISCUSSION

Griswold (9) observed that neutral lead acetate precipitated the anthocyanin pigment in Montmorency cherries. Therefore, it was deemed advisable to ascertain the effect of this salt on the appearance of dry blackeye peas which were soaked, then canned.

Two samples were soaked 8 hours at room temperature, one in water and the other in 2 percent neutral lead acetate solution. The soaking solutions were discarded, then the peas were packed in cans and covered with hot water. The cans were heated for 35 minutes at 240°F.

When opened for examination, the peas treated with lead acetate were free from discoloration. The liquor was slightly turbid but it was not discolored. The eyes of the peas were black and well defined. The peas soaked in water were normally discolored.

Relation of Globulin to Discoloration

Since lead acetate precipitated both water soluble protein (globulin) and anthocyanin, the relation of the globulin to discoloration was determined.

About 4.5 pounds of dry peas were ground in a hand-operated food chopper. The resulting meal was treated twice with petroleum ether to extract the fat. After the meal was dried at room temperature, six 300-gram samples were weighed and extracted with various solutions. These solutions were distilled water, 0.5 N sodium chloride, 1.0 N sodium chloride, 2.0 N sodium chloride, distilled water extraction followed by the addition of enough sodium chloride to the filtered extract to make it approximately 1.0 N, and normal sodium chloride extraction followed by precipitation of the protein by the addition of ammonium sulfate. The precipitate was separated and the liquid of the last solution was treated as a sample.

Different concentrations of sodium chloride were used because the solubility of globulins varies with the concentration of neutral chlorides of monovalent metals, according to Gortner (7).

The samples of meal were placed in large flasks and covered with 1.5 liters of the extraction solution. They were shaken thoroughly several times during the 2-hour period of extraction. After separation by centrifuging followed by filtering, the solid material was discarded.

Several test tubes were filled with portions of each extract, plugged with cotton and autoclaved at 248°F. for 20 minutes.

Portions of the extracts of samples 1, 2, 3, 4 and 5 were analyzed for nitrogen content to determine the amounts of protein extracted. Sample 6 was not analyzed because of the addition of ammonium sulfate. Sample 3 was accidentally destroyed.

There was a noticeable difference in the behavior and appearance of the samples. In every case, where salt was present, coagulation of the protein occurred during the autoclaving process. The precipitates of all samples extracted with salt solutions were lighter in color, even several weeks after autoclaving, than was the sample extracted with water to which salt had been added later (sample 5). The extract that contained no salt did not coagulate (sample 1). The supernatant liquids in all the samples that precipitated were uniform, light straw-yellow and clear. The protein precipitated from sample 6 darkened within a few hours after autoclaving. However, the darkening in all cases was slight and was not comparable with that of darkened canned peas. The protein contents of the extracts are shown in Table 1.

Apparently, the substances extracted by water and dilute salt solutions are not the ones directly responsible for the discoloration of canned blackeye and purple hull peas. Furthermore, the protein normally extracted by these solvents is coagulated by heating in the presence of salt. This is not directly related to discoloration, but, as will be shown later, is significant. The quantity of globulin extracted varied with the concentration of sodium chloride, in accordance with the finding of Gortner (7).

Association of Anthocyanin with Discoloration

Results of the preceding experiments indicated that anthocyanin is the principal component of peas associated with the discoloration of the canned product. To obtain more concrete evidence of this, the following experiment was conducted.

Four samples were prepared in the following manner:

One hundred grams of dry blackeye peas were ground and placed in a flask.

Another 100-gram sample of dry blackeye peas, from which the eyes had been removed, was ground and placed in a flask.

A 100-gram portion of ground dry cream peas was placed in a flask along with the eyes from the blackeyes in sample 2.

One hundred grams of ground dry cream peas were placed in a fourth flask.

Table 1. Protein content of extracts of blackeye peas

Sample	Solvent	Percent protein (N X 6.25)
1	Water	12.79
2	0.5 N sodium chloride	17.90
4	2.0 N sodium chloride	14.61
5	Water[1]	10.41

[1]The slight difference between samples 1 and 5 is probably due, in part, to the dilution of the extract of sample 5 with salt.

One hundred and fifty cubic centimeters of distilled water were added to each flask. The flasks were plugged with cotton and then were heated in the autoclave at 15 pounds pressure for 20 minutes.

The ground whole blackeyes were dark colored, and ground eyeless blackeyes were almost white. The creams with the blackeye were almost as dark as the whole ground blackeyes. This with the observations made in previous experiments, definitely established that the eye pigment is associated with the discoloration of canned blackeye peas.

To study the distribution and behavior of the pigment in greater detail, a microscopic examination was made of some badly discolored commercially canned blackeye peas. Samples of liquor and of the peas were examined. The effect of adding dilute hydrochloric acid or ammonium hydroxide to the sample on the slide was noted, in addition to the gross morphology of the solid particles.

Many, but not all, of the starch granules were brown in color. The liquid portion was almost colorless. Many of the particles of solid material other than starch were tinted a brown or black color. The introduction of hydrochloric acid or ammonium hydroxide had no effect on the color.

From these observations, it is concluded that during the canning process, the pigment was adsorbed on or otherwise attached to the insoluble solids in the pea. The anthocyanin lost its property of changing from red in acid to green in alkaline solution.

To study the behavior of the eye pigment in greater detail, approximately 4.5 pounds of peas were coarsely ground. The meal was placed in a pan. When the pan was filled with water, most of the eyes floated and were skimmed off.

The eyes thus obtained were extracted with 2 percent formic acid solution by placing them in a Waring Blendor with the solvent and blending for about 10 minutes. The mixture was allowed to stand for several hours. Subsequent centrifuging and filtering separated the solid material from the liquid. This crude extract was then shaken with isobutyl alcohol and the alcoholic layer was separated from the aqueous layer.

When the pink alcoholic solution of starch, protein and anthocyanin was treated with ammonium hydroxide, the starch and protein coagulated and formed an amorphous mass.

The anthocyanin turned to a blue-green color and was immediately adsorbed on or otherwise attached to the coagulum. All attempts to dislodge the pigment were unsuccessful, except refluxing the mass with 6 normal hydrochloric acid for about 30 minutes.

Since anthocyanins can be decolorized only by drastic oxidation or reduction, the control of discoloration seemed to be limited to precipitation of the pigment **in situ** or otherwise preventing its disperson. Actual precipitation of the pigment seemed to be out of the question because this can be done only with such toxic reagents as lead acetate. Therefore, the search for a remedy for the undesirable darkening of canned peas was confined largely to a study of treatments and of materials that will inhibit the dispersion of the pigment from its natural location in the eye.

The ideal treatment would be one in which the starch and protein are coagulated and a suitable environment created so that the union of the pigment with the coagulated particles takes place before any dispersion occurs. This effect would be obtained more easily by adding salts to the blanching solution. Therefore, an experiment was conducted to determine the relative effectiveness of several salts and the temperature at which coagulation occurs.

Dry blackeye peas were ground and extracted with water in the same manner as in the preceding experiments. Fifteen cubic centimeter portions of the extract were brought to a concentration of 3.3 percent of various salts by the addition of five cubic centimeters of 10 percent solution of the salt. Chemicals used were none (control), urea, sodium chloride, magnesium sulfate and aluminum sulfate.

Five cubic centimeters of water were added to sample 1. The tubes were immersed in a water bath equipped with a mechanical stirring device. A thermometer was inserted in a test tube containing 20 cubic centimeters of water. The temperature of the bath was raised slowly at a fairly uniform rate and the temperature at which coagulation occurred was noted. After the preliminary treatment, all the tubes were plugged with cotton and autoclaved. The results and observations are shown in Table 2.

There was a striking difference between the coagulating ability of the inorganic salts. This is in agreement with the Hardy-Schulze rule that "the precipitating power of an electrolyte depends upon the valence of the ion whose charge is opposite to that on the colloidal particle." From this it was concluded that the particles precipitated from the pea extract were negatively charged. Gortner (6) stated that "the in-

Table 2. Temperature of coagulation of pea globulin in the presence of various salts

Salt	Normality of salt	Temperature of coagulation (deg. F.)	Appearance of precipitate one week after autoclaving
None (Control)	0	185[1]	
Urea	—	144	Almost black
Sodium chloride	0.57	161-168	Very slight darkening compared with overall appearance of control.
Magnesium sulfate	0.26	132	Very slight darkening
Aluminum sulfate	0.27	82[2]	Uniform straw-colored gel; weeping

[1]Only very slight flocculation which disappeared after autoclaving.
[2]Room temperature.

fluence of valence is not an arithmetical 1:2:3 ratio but more nearly a geometrical progression 1: $\times$: $\times^2$." The results of this experiment agree with Gortner's principle.

It is realized that these conclusions would be somewhat less open to question if sodium sulfate had been included in the series. However, the primary object of this experiment was not to determine the charge of the particles but to determine the coagulating ability of various salts which could be used in the blanch solution in commercial practice. The charge on the particles is of minor significance since anthocyanins are amphoteric and are readily adsorbed on either positively or negatively charged particles, provided the pH is correct.

In view of the foregoing observations, an experiment was designed to determine the effect of sodium chloride, magnesium sulfate and aluminum sulfate, when used in the blanching solution, on the appearance of the canned peas. Urea was omitted because of the black precipitate formed in its presence.

A sample of fresh green-shelled purple hull peas was blanched in each of the following solutions: water, 2 percent chloride, 2 percent magnesium sulfate, 0.5 percent aluminum sulfate and 0.25 percent aluminum sulfate. A blanch temperature of 185 to 190° F. was used. The peas were immersed in the blanch solution for 4 minutes. They were then washed and canned in the usual manner.

Twelve days later, there were no differences in any of the samples except those blanched in 0.5 percent aluminum sulfate. Those peas were darkened slightly less than the others.

Since the coagulation of the starch and protein stopped the further spread of the anthocyanin, it was assumed that the lapse of time between sealing the cans and processing them was a factor in the discoloration of the peas. To ascertain whether this was correct, small lots of peas were blanched 4 minutes at 185° F. After cooling them by washing in cold water, each lot was placed in a can, covered with boiling water, sealed, and placed in the autoclave. The time was noted when the boiling water was added.

One sample was canned at each 5-minute interval. When the last can was placed in the autoclave, it was closed and brought to 240° F. as rapidly as possible. Thus, samples were obtained which had been held various lengths of time prior to beginning the sterilization process.

No difference was noted between the samples of peas. Those held 27 minutes appeared the same as those held only 2 minutes prior to the time that the retort reached 240° F. Therefore, the interval between sealing and processing is not critical.

Since coagulation of the starch and protein early in the canning procedure is desirable, it was assumed that the use of a higher temperature during the sterilization process would be advantageous in bringing about the desired effect more rapidly. In fact, this had already been found to be the case by Blair and Ayers (2) with English peas. They recommended a process time and temperature of 7 minutes at 260° F. With these facts in mind, two lots of peas were packed.

One lot was processed 7 minutes at 260° F. and the other for 30 minutes at 240° F. The peas cooked at the higher temperature were very much greener and less discolored than the peas cooked at 240° F. The liquor of the former, however, was much darker.

The findings of the preceding experiments were combined in designing an experiment to determine the interaction of salts in the blanch and different processing times and temperatures.

A sample of fresh green-shelled purple hull peas was blanched 4 minutes at 185° F. in 4 percent magnesium sulfate and another in 1 percent aluminum sulfate and water. They were then placed in cans, covered with water and sealed.

Some of the cans from each treatment were cooked in each of the following sterilization processes: 53 minutes at 235° F., 11 minutes at 260° F. and 35 minutes at 240° F. Examination revealed that the use of aluminum sulfate reduced discoloration.

With only one exception, the peas cooked at the lower temperatures were inferior to those cooked at the higher temperatures. The use of magnesium sulfate increased the toughness of the peas so much that this compound was discarded.

Table 3 indicates the treatments in their relative order to desirability of the basis of color.

This experiment was repeated on blackeye peas with almost identical results.

Subsequent experiments conducted in a similar manner showed that ammonium alum ($Al(NH_4)(SO_4)_2.12H_2O$) is only slightly less effective than aluminum sulfate. This difference probably is due to the fact that ammonium alum contains approximately 8.09 percent of the metal.

A beneficial side effect was noted when aluminum salts were used in the blanching solution. The viscosity of the liquor and the severity of gelling were reduced markedly by the aluminum treatments. No attempts were made to obtain quantitative data on this effect.

The Blair and Ayres process for canning English peas (2) involves a pre-processing soak containing calcium hydroxide, a cover brine containing magnesium hydroxide and the previously mentioned high-temperature and short-time steriliza-

Table 3. Relative desirability of various blanching solutions and sterilization processes

Relative desirability	Blanching solution	Sterilization process Time (min.)	Temp. (deg. F.)
1[1]	1% aluminum sulfate	11	260
2	4% aluminum sulfate	35	240
3	1% aluminum sulfate	35	240
4	1% aluminum sulfate	53	235
5	4% magnesium sulfate	11	260
6	4% magnesium sulfate	53	235
7	Water	11	260
8	Water	35	240
9[2]	Water	53	235

[1]Most desirable.
[2]Least desirable.

tion process. It was believed that the first, second and fourth of these treatments, if suitably modified, could be applied to the processing of Southern peas. In fact, the use of a special blanching solution and the use of the high-temperature and short-time process had already been proved to be of value.

To determine the effectiveness of the pre-processing soak, fresh green-shelled blackeye peas were soaked 1 hour at room temperature in 0 (control), 0.5, 0.75, and 1.0 percent ammonium alum solutions. They were then blanched in 1 percent ammonium alum solution and canned in the usual manner. No differences were noted between any of the treatments.

Since the sulfate ion exerts a dispersing rather than a coagulating influence on starch (8), it was supposed that aluminum chloride and magnesium chloride would be more effective than the corresponding sulfates in controlling discoloration. To determine whether this was correct, peas were blanched in various concentrations of these chemicals. It was found that the supposition was incorrect.

Up to this point, the examination of the peas had been carried out in an informal, subjective manner. This method, while the simplest and easiest possible, is subject to much human error and prejudice. In addition, the method provided no adequate quantitative description of how different lots of peas vary in desirability. The following series of experiments was designed to provide objective data.

A bushel of fresh green-shelled blackeye peas was divided into 16 portions and canned in such a manner that samples were available which had been blanched in water and the 1, 2, 3, 4 and 5 percent levels of magnesium chloride, aluminum-chloride and ammonium alum. These samples of peas were subjected to the following tests: organoleptic examination for the attributes of color, flavor, tenderness and amount of splits; objective measurement of the color of the ground dried peas; and objective measurement of the color of a paste prepared from the peas.

The first of these tests was carried out in two phases. One was the organoleptic evaluation of the samples on the basis of flavor, tenderness, splits and defects. These data, in summary form, are presented in Table 4. From them it is apparent that there is little deterioration in flavor up to and including the 3 percent level of alum in the blanch water. There was little difference in the tenderness or splitting of the peas regardless of the concentration of alum or aluminum chloride in the blanch. Only two samples of

Table 4. Flavor, tenderness and splitting of blackeye peas blanched in various solutions

Blanch solution	Number of judges	Flavor[1]	Tenderness[1]	Splits[1]
Water	2	7.0	8.0	8.0
2% magnesium	2	6.0	7.0	8.0
		Alum		
Water	4	6.0	5.5	6.5
1% alum	4	6.0	6.3	8.0
2% alum	4	6.3	5.5	7.5
3% alum	4	5.5	7.0	7.5
4% alum	4	3.8	6.8	7.5
		Aluminum chloride		
Water	5	7.0	7.6	7.0
1% aluminum chloride	5	6.6	6.4	6.5
2% aluminum chloride	5	6.2	6.2	7.2
3% aluminum chloride	5	6.4	6.4	7.0
4% aluminum chloride	5	6.6	6.6	6.5
5% aluminum chloride	5	6.8	6.6	6.2

[1]These numbers represent numerical opinions of the judges. The word description of each number in the scale is given below:

0—repulsive	4—fair	8—very good
1—very poor	5—acceptable	9—excellent
2—poor	6—fairly good	10—ideal
3—poorly fair	7—good	

peas blanched in magnesium chloride were examined by the judging panel because there was obvious deterioration of color of the product with increased concentrations of that salt. This is just as well, because the increase in concentration of magnesium chloride also increased the toughness of the peas.

The subjective evaluation of the color of the aluminum chloride- and alum-blanched peas was carried out in a more elaborate manner. Two replicates were prepared, with duplicate samples in each. Thus, four groups of samples were judged. Eight testers rendered their individual written opinions on each group of samples, as shown in Table 5.

These opinions were assembled and subjected to an analysis of variance. The analysis revealed that there was good agreement between testers and that they were consistent when the duplicates and replicates were considered.

There was a significant increase in the desirability of the peas with each increase in concentration of alum in the blanching solution up to and including 4 percent. The 5 percent level was omitted in this evaluation because of a lack of samples. The same difference of color occurred in the peas blanched in aluminum chloride, except that the increase in desirability was less pronounced. There was a slight decrease in desirability between the 4 and 5 percent levels of this salt in the blanch solution. These data are shown graphically in Figure 1.

For a given concentration of aluminum, a more pronounced improvement in color results if the metal is supplied in the form of alum. This is presented in Figure 2.

Objective measurement of the color of whole peas was not considered feasible because colorimeters make use of only a small field of observation, and since the eyes of the peas normally are dark, the readings would be valueless unless a large number were made. Since it has been established that the discoloring substance was always present and the extent of discoloration depended for the most part on its distribution, the obvious conclusion was that any method of determination

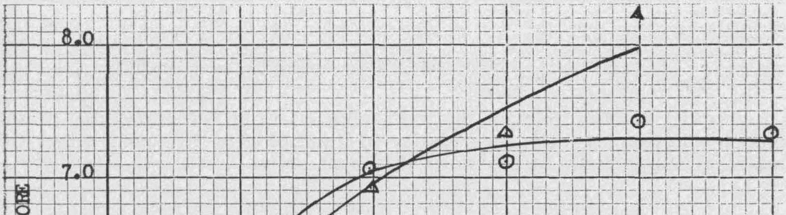

Figure 1. The relation between concentration of aluminum salts in the blanch solution and the desirability of the color of the peas.

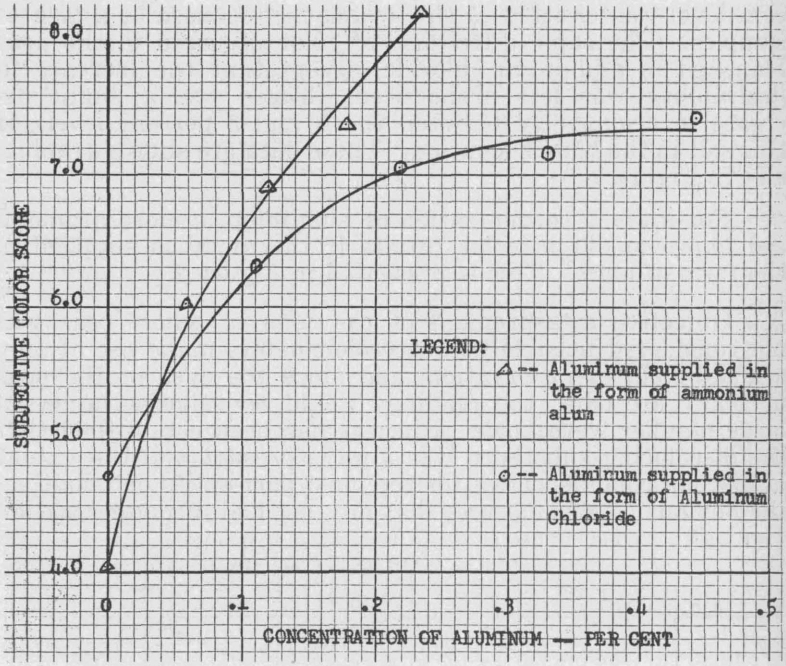

Figure 2. The relation between concentration of aluminum in the blanch solution and the desirability of the color of the peas when the metal is supplied in the form of different salts.

which relied on conversion of the peas to a more or less homogeneous mixture would not be successful. To check this hypothesis the following experiment was conducted.

A sample of Fischer's adsorption alumina was treated with a solution of amaranth, a food coloring dye, so that approximately eight milligrams of dye were evenly distributed over the particles in each gram of alumina. Samples of this dark red alumina were mixed with untreated alumina so that concentrations of 0.25, 0.5, 0.75, 1.0 and 1.25 milligrams of amaranth per gram of alumina were obtained. Five more samples were prepared which contained the same concentrations of dye, but upon whose particles the color was evenly distributed. Measurements of the color of these samples were made by using a Photovolt reflectometer.

From the amber, green and blue readings, the corresponding x and y values were calculated according to the method described by Hunter (12). These figures were then applied to charts in the manner described by Nickerson (20) to obtain the appropriate Munsell color notation for the color measured. The difference in colors was determined by using Nickerson's (19) formula for small color differences:

$$I = (c/5) \bullet (2dH) - 6dV - 3dC$$

Where: I = Index of color change; C = Munsell chroma; V = Munsell value; H = Munsell hue; dC = Change in chroma; dV = Change in value; and dH = Change in hue.

The color of untreated alumina was measured and used as the base from which color changes were calculated. The color indices of the alumina have been plotted against concentration of the dye. Figure 3 shows that, for any one concentrated pigment, considerable variation of color is possible through changes in the distribution of dye adsorbent.

Through an analagous consideration of a meal prepared from dried peas, it would appear that, if comparisons were confined to one group of samples which differed only in treatment, the color index would be a good measurement of the

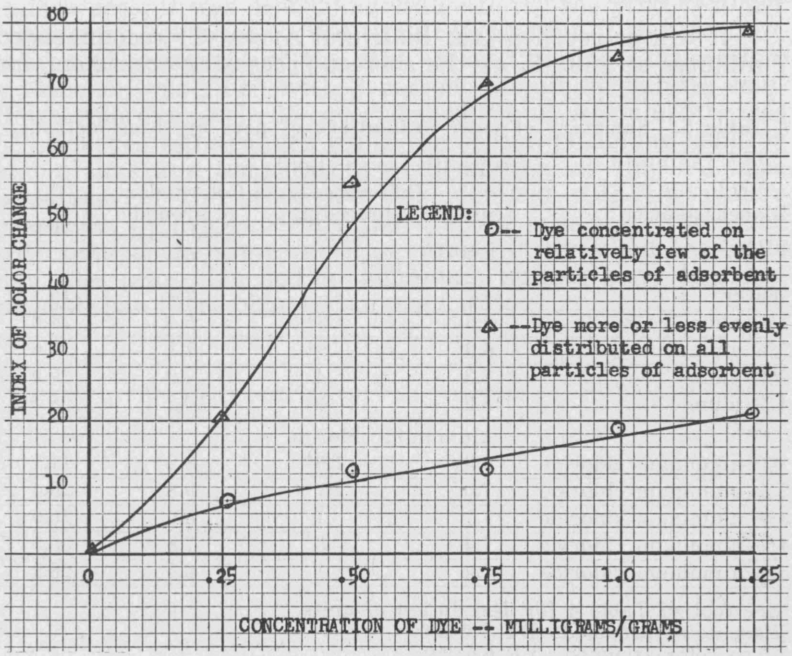

Figure 3. Effect of the manner of distribution of amaranth on the color of the alumina.

severity of discoloration. The validity of this reasoning was determined in the following manner.

Two samples were withdrawn from each bowl of peas in the preceding experiment immediately after the eight testers had finished their evaluation. One sample from each bowl was placed in a vacuum oven and dried at 70° C. After being taken from the oven, the samples were ground through a 40-mesh screen in a Wiley mill. The color of each sample was measured and the color index calculated by the method already described.

A 50-gram sample of peas from each bowl was weighed and blended with 50 cubic centimeters of water for 5 minutes in a Waring Blendor. The resulting paste was deareated by placing it *in vacuo* for 15 minutes. The color was measured as in the preceding experiments.

The resulting color indices are presented along with the subjective evaluations in Table 5. It may be seen that the indices derived by these methods are not suitable for an objective color comparison of the desirability of the canned blackeye peas.

It will be recalled that Blair and Ayres (2) recommended 7 minutes at 260° F. as the correct processing treatment for

Table 5. Summary of color evaluations of peas by three methods

Blanch solution	Subjective evaluation[1] Score	Subjective evaluation[1] Difference from preceding value	Color index of ground dried peas[2]	Color index of paste[3]
		Alum		
Water	4.1	—	2.4	15.3
1% alum	6.0	1.9[4]	6.4	21.0
2% alum	6.9	.9[4]	7.1	20.6
3% alum	7.3	.4	7.9	27.9
4% alum	8.2	.9[4]	10.2	28.3
		Aluminum chloride		
1% aluminum chloride	6.3	1.6[5]	8.2	11.1
2% aluminum chloride	7.0	.7	9.8	26.4
3% aluminum chloride	7.1	.1	5.0	20.0
4% aluminum chloride	7.4	.3	7.8	30.5
5% aluminum chloride	7.3	.1	6.6	28.2

[1]See foot of Table 4 for description of units.
[2]Base color assumed—DY 7.0/2.0.
[3]Base color assumed—YR 6.0/3.0.
[4]Least significant difference at the .01 level—.7; at the .05 level—.5.
[5]Least significant difference at the .01 level—1.1; at the .05 level—.8.

English peas treated by their technique. The final pH of the "Blair-processed" peas is near 7.8. The pH of normal Southern peas is near 6.3 and that of alum-blanched peas about 6.1. This would indicate that a somewhat shorter process at that temperature might be adequate for the sterilization of blackeye and purple hull peas.

Facilities were not available for cooling the cans in the retort while maintaining pressure, so a conventional-type retort was used. The peas were placed in the retort and the temperature raised to 260° F. as quickly as possible. After processing for a prescribed period of time, the steam pressure was released and the cans cooled immediately. Even with precautions taken to prevent mechanical stresses from injuring the cans, four developed obvious leaks and four had buckled tops. Thus, nearly 2.8 percent of the cans were damaged. Therefore, it must be concluded that, without pressurized cooling equipment, high-temperature and short-time sterilization of blackeye and purple hull peas is impractical.

Since the use of a 2 to 3 percent alum or aluminum sulfate solution as a blanch improved the color of small lots of canned peas, it was deemed advisable to try the process under commercial conditions. With the cooperation of the management and personnel of the Mid-Valley Canning Corporation, a blancher was filled with 3 percent aluminum sulfate solution. Approximately 25 cases of purple hull peas and 30 cases of blackeyes were canned using the special blanching solution and a time and temperature of 5 minutes at 190° F. The remainder of the procedure was identical with the plant's operation. When experimentally-packed peas were compared with peas of the same varieties canned in the plant the same day, the peas blanched in aluminum sulfate were less discolored than those blanched in plain water.

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