THE EFFECTS OF GRADE AND COLOR UPON THE PERFORMANCE OF TEXAS COTTON

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BY

CAROLYN ANNETTE KIRKPATRICK, B. S.

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Texas Woman's University

Denton, Texas

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We hereby recommend that the thesis prepared under our supervision by Carolyn Annette Kirkpatrick entitled "The Effects of Grade and Color Upon the Performance of Texas Cotton"

be accepted as fulfilling this part of the requirements for the Degree of Master of Science.

Committee:

Esther R. Broome
Chairman

Pauline Beery Mack

Bethel M. Caster

Dorothy M. Harvey

Accepted:

T. L. Morrison
Dean of Graduate Studies

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INTRODUCTION

This study was undertaken in an attempt to measure the effects of color and grade upon the scouring and/or bleaching properties of Texas cotton. Twelve fabrics knitted from four colors of Middling, Strict Low Middling, and Low Middling grades of cotton served as experimental fabrics for the study. They were subjected to extensive periods of exposure to laundering and to sunlight and analyzed with reference to their performance.

For many years the processors of Upland cotton produced in Texas have been faced with problems which have arisen from the discoloration and immaturity of much of the annual cotton crop. The solution to these problems has not proved to be a simple one since so many factors, some beyond the control of man, are involved.

Various conditions contribute to the discoloration of cotton fibers. Exposure to weathering as the cotton stands in fields before being harvested causes yellowing or darkening from the natural color of the cotton. Cotton bolls after opening often become wet while they remain on the stalk, and at the points where bits of stalk and leaves touch the moist fibers, dark spots or discolorations are formed. When drought or frost stop the growth of cotton fibers prematurely, a color change of varying depths of yellowness occurs. The action of microorganisms, insects, and fungi, and the settling of dirt and dust are also responsible for undesirable colors and grades of cotton.

Along with these naturally instigated discolorations of cotton exists the possibility of stains which might be caused by mechanical harvesting equipment. In some instances cotton is stained by oil or grease from the equipment, whereas in other instances green leaves and other parts of the plants become crushed and further stain the cotton fiber as it is being processed.

Stained or spotted cotton fibers when spun into yarns and processed into fabrics show up as darkened spots in the fabric and thus must be overcome by the converter if the cotton industry of the State of Texas is to survive economically. The seriousness of this situation has prompted a desire on the part of the author of this thesis to make a contribution to the cotton industry by conducting an extensive study of the effectiveness of a variety of treatments designed to remove discolorations from cotton.

OBJECTIVES OF THE STUDY

The specific objectives of the study were as follows:

1. To secure twelve fabrics knitted from three grades and four colors of Texas cotton;

2. To divide each of the fabrics into five sets to be subjected to the following methods of treatment:

   Set 1 . . . . No Treatment--Greige

   Set 2 . . . . Soap and Water Scouring

   Set 3 . . . . Caustic Scouring

   Set 4 . . . . Sodium Hypochlorite Bleaching

   Set 5 . . . . Hydrogen Peroxide Bleaching;

3. To subject each set of the experimental fabrics to 25 laundering periods in a home washer at 140 ± 2^{o} F.;

4. To measure the reflectance of the laundered fabrics by means of the Hunter Multipurpose Reflectometer, initially, and after five, 10, 15, 20, and 25 periods of laundering;

5. To evaluate the bursting strength of the laundered fabrics at the periods mentioned in Objective 4;

6. To expose the experimental fabrics to 80 hours of sunlight in an Atlas Fade-Ometer;

7. To determine the reflectance of the fabrics initially and after each 20 hours of exposure

to light by means of the Beckman DU Spectrophotometer;

8. To analyze the data with reference to the effect of scouring, bleaching, laundering, and light.

REVIEW OF LITERATURE

Cotton, one of the major agricultural commodities of Texas, has always excelled as a textile product. Now, however, the cotton industry must keep abreast with technological advancement, if cotton is to maintain the position it has enjoyed in the past. Research projects related to fiber quality, the removal of impurities, and the utilization of Texas cottons of various fiber properties have been undertaken as a means of contributing toward the maintenance of this position.

Niles (20) in a report of studies conducted in Texas in the area of fiber quality pointed out that with mechanical picking the periods of field exposure of mature cotton are often considerable. He also mentioned that experience and observation indicated that, while there are differences among genotypes with reference to inherent whiteness and luster of fiber, there are also differences in the degree to which these grade characteristics are retained during exposure in the field. In a particular program conducted at the Agricultural and Mechanical College of Texas the lint grade equivalents in some cases dropped from three to five grades due to field exposure according to the report.

Cox (10) in reporting harvesting research studies conducted at Texas Tech stated that different harvesting methods had no significant effect on the fiber and spinning performance but did have a pronounced effect on the net cash return to the producer. In one instance over-stripping after frost gave the highest net cash return. The effects on the spinning performance were attributed to the time of harvest and to the Micronaire level at that particular time. Field exposure generally resulted in discoloration which reduced grade, and microbiological damage was found to increase the short fiber content which is not detected in classing or in an increased tendency for fibers to break during processing.

Cox further stated that the improvement of color from Spotted grades to Light Spotted grades, rather than improvement in staple, usually resulted in a total net gain; however, in the case of many Light Spotted grades, improvement to White grades rather than improved staple could result in a net loss in several of the staples in case of an accompanying significant decrease in lint turn out.

Metcalf (18) found, in a study of cotton stored during the marketing years of 1961-1962, that cotton stored 120 days performed as well or better than cotton ginned immediately after harvest, even though slight variations in grade and staple occurred during storage. This indicated that the differences found in grade and staple were not real but associated or that the present grading system does not reflect mill performance. Other fiber qualities which varied significantly were strength, elongation, upper half mean length, mean length, uniformity ratio, and the content of large and small trash. No patterns were present and variations by length of storage were not consistent for both years.

Metcalf further reported that after 120 days of storage, all of the cotton was valued at about the same amount as before storage. However, changes in the market value of the lint did occur during the storage period for both years. Implications are made that no costs or value deterioration must be accounted for due to loss of value of cotton stored prior to ginning. No changes were differentiated in fiber quality by the type of storage.

The effects of field exposure on cotton color were shown in a study reported by Smith (22). Bolls of cotton which opened the same day were identified and samples were picked and measured each week for twenty-seven weeks. While twenty-seven weeks is much longer than cotton is usually allowed to remain in the field before harvesting, the results showed that the color of the cotton became progressively darker as the weeks went by.

In a comparison study by Ware and Benedict (24) of colored Upland cotton from the Soviet Union and America and American white Upland cottons, the colored cottons did not measure up to the white cotton level. In determining lint percentage, length, strength, and fineness, all properties were found to be too low for commercial utilization. Spinning tests seemed to bear out evidence of poor quality which was indicated in the colored cottons by laboratory tests.

Investigations reported in the Encyclopedia of Textile Works (3), in regard to the natural impurities in cotton, have indicated the presence of at least five different constituents. One impurity was found to be a wax-like body commonly designated as cotton wax, which is insoluble in and lighter than water, and which has a comparatively high melting point. A thin coating of this wax on the surface of the fiber probably accounts for raw cotton being difficult to wet out. Another impurity appears to be either margaric acid or a mixture of palmitic and stearic acids; it is a fatty matter that melts at 55° C. Also present are nitrogenous, non-crystalline brownish coloring matter and a light amorphous substance of an acid character which resembles certain gums and is known as pectic acid. Albuminous matter exists in small quantities, whereas pectic acid and coloring matter are present in larger proportions. The other constituents were found to be present in very small quantities.

The difficulties encountered by the converter as a result of the natural and acquired impurities found in cotton have led to a need for effective methods for removing such impurities. The American Cotton Handbook (17) recommends treatment with hot alkaline detergent or with hot soap solution as one scouring method. Pressure kier boiling is another important and commonly used method recommended for the removal of foreign matter from cotton prior to bleaching.

According to Nettles (19), cotton contains impurities which are present in the fiber as it occurs in nature and which necessitate bleaching. Sodium hypochlorite has been found to present certain advantages when used in bleaching cotton. It is inexpensive and goods treated with it need a less severe alkaline pre-scour because the necessary pH for hypochlorite stability (9.5 - 11 pH) is above the pH at which minimum fiber degredation occurs.

Nettles further stated that fabrics pre-treated with hypochlorite appear to be more easily bleached by alkaline peroxide bleaching than those not treated, therefore a cheaper peroxide bleaching system can be devised since the products formed by the reactions of hypochlorite and nitrogenous proteins are more easily oxidized than untreated peroxide materials. Since peroxide has been found to be an effective antichlor, interest has been created in "one-shot" scour and bleaching formulations using both hypochlorite and peroxide.

Haeusermann and Hableulzel (14) discussed the influence of steaming time and sodium chlorite concentration on the degree of whiteness in bleaching by the impregnation-steam principle. The study included chlorite consumption investigations. The investigators concluded that the degree of whiteness first rises linearly with the steaming time and reaches a maximum value after a definite time interval which is dependent on the chlorite concentration. Beyond this, an increase in treatment time no longer influences the degree of whiteness but may still be effective for the complete elimination of motes in the cotton. Chlorite consumption is greatest at the beginning of the bleaching and reaches a practical end value long before the degree of whiteness has reached its maximum. The chlorite residual value remains at this level even if the steaming time is prolonged. This finding did not coincide with observations of the chlorite decomposition of greatly dilute solutions. The cause for this difference still remains to be determined. As a result of the study, it was concluded also that pure, highly polymerized cotton cellulose does not consume any chlorite.

Haeusermann and Hableulzel also discussed the relationship of chlorite decomposition and use with time, even though no bleaching effect was concerned. They found that a "first order" reaction takes place with a textile fabric present, especially when using high ratios of liquor. Since impurities on the fiber are not free moving bodies, the bleaching process takes place in a heterogeneous phase only on the surface or on solid-liquid boundary areas. It is dependent on the speed of diffusion and is assumed in a similar manner to that of a dye process which can be speeded up through stirring or agitation. A "second order" reaction takes place on the fiber. The speed of this reaction is dependent on the concentration of the bleaching medium and on impurities in the fabric which act as redox agents. This determines the frequency of interaction of the reacting particles. The second order reaction takes place between the bleaching agent and the coloring matter of the impurities The cotton itself was found not to undergo any reaction with chlorite. This was concluded on the basis that if it did consume chlorite, the chlorite consumption would increase constantly throughout the steaming process.

Evans (12) also reported factors found to be important in chlorite bleaching. A pH of 4 in a chlorite bleach bath has been found to be desirable when buffered with an acid and/or an acid salt. Bleaching temperatures of about 100 degrees Centigrade were found to be desirable. Temperature was of particular importance since bleaching rate and chemical breakdown were found to be dependent on this factor. Above 100 degrees Centigrade, chlorite consumption was excessive and the dangers of tendering the cotton fabric increased rapidly. When cloth temperature was uneven, bleaching was also uneven. Fabric damage by tendering also occurred rapidly as wetness decreased. The chlorite treatment oxidized the cotton waxes so that they were readily removed by a final mild alkaline scour.

In a study conducted for the purpose of investigating localized chemical damage to cotton through peroxide bleaching, Boyha, Hubbard, and Martin (7) found that the formation of small holes and weak areas was caused by the presence of metallic contaminants in the cotton fabric prior to bleaching. Since literature revealed conflicting statements regarding the effect of iron and copper compounds on fabric during bleaching, the study was undertaken to resolve the problem. Rust formed by iron oxidation in direct contact with the fabric caused severe damage to the fabric during bleaching, but other iron compounds were not harmful. Copper and copper compounds caused severe damage during bleaching. The composition of grease used to lubricate bearings and containing copper affected the extent of fabric damage caused by the grease during bleaching. Treatment of contaminated fabrics with dilute mineral acids prior to bleaching helped prevent fabric damage during bleaching by removing copper soaps from used greases. Of the additives to the bleaching solutions which were studied, chelating agents based on diethylenetriamine pentaacetate were most effective in preventing damage caused by metallic contamination in commercial two stage hydrogen peroxide bleaching procedures.

A very important phase of cotton research has been conducted in the Cotton Utilization and Finishing Laboratories at Texas Woman's University for a number of years. According to Mack (16) the purpose of this research has been to find by investigations related to cotton fabric how Texas cottons of various fiber properties can be utilized in such a way as to produce cloth for wearing apparel, household textiles, and agricultural and industrial uses which will have excellent acceptance by the ultimate consumer.

One of the first of these studies was conducted by Skiles (21) who studied the effect of the Micronaire of cotton on the laboratory performance of specially woven sheets. The sheets were made from 18 bales of cotton chosen for property similarities except for Micronaire which ranged from very fine to very coarse (5.7 - 5.8 to 2.8 - 2.3 Micronaire). The study was devised to determine whether or not fine-fibered, immature cotton could perform satisfactorily in a typical household fabric requiring durability. The sheets were tested in the greige state before and after de-waxing and in the bleached state before and after desizing. Skiles found that the sheets made of the cotton having the lower Micronaire values, the cotton of greatest interest because of its frequency in Texas, showed a number of factors in which they were better than or little different from sheets made of the preferred intermediate Micronaire values.

Klein (15) continued studying the effect of Micronaire by working with the development of direct dye formulations to produce fashion colors in cottons of various Micronaire. Direct dye formulas were applied to six cotton fabrics which represented a broad range of Micronaire. All other properties of the cotton were relatively constant. The number of dyes used in the formulas were not found to constitute a particular problem in the dyeing of these cottons of various Micronaire values.

Brakebill (9) also investigated the relationship between the fiber properties of cotton and its dyeing behavior. The project examined the possible variables in cotton fibers which might affect the dyeing properties of yarns made of certain selected cottons and investigated the effect of Micronaire, variety, location, and year of growth of the fiber, as well as the yarn number and twist multiplier of the yarn on the color of the fiber pigmented with designated vat and azoic dyes. Yarns of domestic cottons, collected by the staff of the Cotton Economic Research Laboratories of the University of Texas were used in the study. Most of the cottons were grown in Texas; a few were grown in Mexico; and one was grown in California. The selected yarns were each dyed in two groups. One group was dyed with a vat dye of high molecular weight and the other group with an azoic dye of low molecular weight. Brakebill found that a fiber condition or property might affect the two types of dyes in different ways or that it might affect the reflectance of the cotton dyed with one dye and not the other. The greatest variations in dyeing seemed to be produced by the location of growth and the Micronaire values.

Another study involving the effect of Micronaire on dyeing behavior was conducted by Brakebill (8). The effect of the molecular weight of dyes on the absorption by six different levels of Micronaire was explored. The finding of this study showed to a limited degree that the molecular weights of direct dyes could be related to the deviation in classes of optical density differences shown when a dye was applied to a series of six Micronaire groups of cotton. The vat dyed cottons showed a wider dispersion.

Thomas (23) evaluated the wash and wear properties of 24 specially woven cotton fabrics having different Micronaire values and fabric geometry and treated with two wash-and-wear chemical formulations. The fabrics consisted of 24 combinations of fiber Micronaire and variations of yarn twist in the warp and filling directions. The warp yarns consisted of Micronaire levels of 3.0, 4.0, and 5.0 and had a twist multiplier of 4.20. The filling yarns had Micronaire values of 2.5, 3.0, 4.0, 5.0, and 6.0 with twist multipliers of 3.60 and 4.60. The fabrics were evaluated in the greige state, after bleaching and mercerizing, and after the application of a melamine formaldehyde and a cross-linked wash-and-wear finish. The investigation disclosed that dry tensile strength, both in warp and filling directions, was markedly influenced by the Micronaire and yarn twist values of the cotton fabrics. Those fabrics having twists of 3.60 and relative fineness in filling fibers showed that the greatest resistance to warp and filling breaking in the warp tests was produced by the 3.60 twist multiplier. Strength values tended to decrease with finer filling Micronaire. In the cross-linked finishes, the 3.60 twist multiplier yarns continued to exhibit superior strength in warp testing while the 4.80 yarns were stronger in the filling testing. Some tendency was observed in the warp strength for the 5.0 warp Micronaire to possess the least resistance to tearing while no relationship of Micronaire to tearing strength was evident from tests made in the filling direction.

The effect of Micronaire was again explored by Bailey (5) in an in-use study of the performance of cotton sheets. Of the 1,905 sheets in the study, 1,745 were made of Texas cottons of various Micronaire values. The ultimate goal of the investigation was to determine the relationship between the fiber properties and the overall behavior of the fabrics in order to determine whether or not a fine-fibered, immature cotton or a cotton of a coarser Micronaire value could perform satisfactorily in a typical household fabric requiring durability. Bailey found that, in data pooled from one to 40 weeks of use and laundering in the filling direction and one to 60 weeks in the warp direction, there was a slight trend in favor of sheets from Micronaire values 5.1, 4.1 - 4.0, and 3.7 - 3.4 in tensile strength. There was no statistical difference between any of the types of sheets after 130 weeks of use and laundering with respect to tearing strength. From this, it was evident that Micronaire value was not a determining factor relative to the resistance of these fabrics to tearing. At the conclusion of the study statistical comparisons did not reveal any significant difference between the sheets with respect to their resistance to flexing and abrasion. It was determined when data were pooled for each respective type of sheet after 130 weeks of use and laundering that the Micronaire values did not affect the loss due to flexing and abrasion, flat abrasion, and bursting.

Bendy (6) investigated the effects of fiber Micronaire and yarn twist upon the abrasion resistance of cotton sheeting. The study included the 24 specially woven variations of Type 128 cotton sheeting studied by Thomas (23). The objective of the investigation was to determine the effects of varying cotton Micronaire values and yarn twist multipliers upon the abrasion resistance of the experimental fabrics in the greige state, after bleaching and mercerizing, and after treatment with urea formaldehyde finish, and a cross-linkage type of finish, respectively. Bendy found that warp yarns containing 4.0 Micronaire fibers were superior in flexing and abrasion and in flat abrasion, in more instances than were the other Micronaire levels. In the filling direction a Micronaire of 2.5 was found to be superior most often.

PLAN OF PROCEDURE

Twelve experimental fabrics representing three grades and four colors of Texas cotton were used in this study. The fabrics were constructed into 22 gauge circular knit by Enterprise Incorporated of Dallas, Texas, from 22/1 yarns spun from each of the respective classifications of cotton shown below:

CLASSIFICATION OF EXPERIMENTAL COTTON

Lot	Grade	Color
1	Middling	White
2	Strict Low Middling	White
3	Low Middling	White
4	Middling	Light Spotted
5	Strict Low Middling	Light Spotted
6	Low Middling	Light Spotted
7	Middling	Spotted
8	Strict Low Middling	Spotted
9	Low Middling	Spotted
10	Middling	Tinged
11	Strict Low Middling	Tinged
12	Low Middling	Tinged

Specimens representative of the twelve fabrics in the greige state are shown in Figure 1.

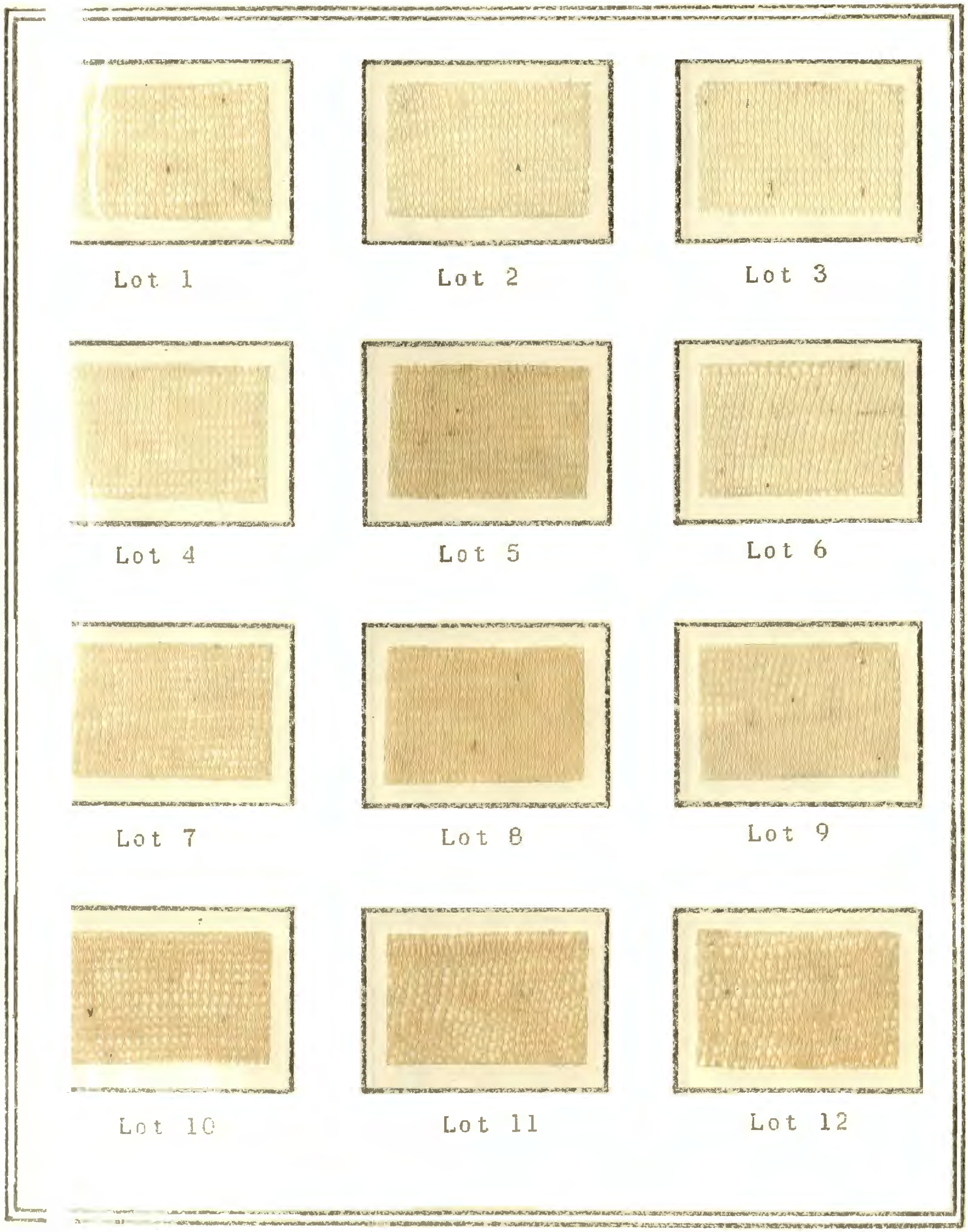

FIGURE 1

EXPERIMENTAL FABRICS IN THE GREIGE STATE

PREPARATION OF EXPERIMENTAL FABRICS

In preparation for the analysis of the fabrics each was divided into five sets of sufficient length to provide specimens for the various tests planned for the study. The five lengths of fabrics were coded into sets which designated the treatment to which they were to be subjected as shown below:

Set Number	Treatment
Set 1	No Treatment--Greige
Set 2	Soap and Water Scour
Set 3	Caustic Soda Scour
Set 4	Hypochlorite Bleach
Set 5	Hydrogen Peroxide Bleach

SOAP AND WATER SCOURING

Each fabric in Set 2 was placed into a separate container with a boiling solution of 0.2088 grams of neutral soap and 25 milliliters of water per gram of fabric and boiled for 10 minutes. Afterward the fabrics were rinsed first in hot water and then later in cold water until the impurities were flushed away. They were neutralized with an acetic acid solution, and a Coleman Metrion IV Model 28C pH meter was used to determine the neutral point. After neutralization the fabrics were blocked to their original shape, placed flat on a padded table, and air dried.

CAUSTIC SODA SCOURING

Set 3 of the experimental fabrics was subjected to a simulated kier boiling process much like that described in the American Cotton Handbook (17) except that a home-type pressure cooker was used instead of a kier. In each step of the process the fabrics were treated on an individual basis to avoid the intermingling of colors.

The fabrics were wet out in boiling water until thoroughly saturated. They were squeezed to remove excess water and then placed in glass jars which contained a 10:1 ratio of liquid to fabric of a scouring solution composed of the following ingredients: 1.5 per cent sodium hydroxide, and 0.25 per cent of sodium carbonate, sodium silicate, and pine oil soap, respectively, based on the volume of the liquid. The containers were covered with glass-lined zinc lids and placed on the rack of the pressure cooker. The pressure was raised to 15 pounds per square inch (250° F.) and maintained for 10 minutes but was allowed to drop completely before the cooker was opened for the removal of the specimen. The fabrics were then subjected to a hot water wash followed by a cold water wash to flush away dissolved substances. They were neutralized with an acetic acid bath and after processing were blocked to their original shape before drying to establish uniformity in the preparation of test specimens.

SODIUM HYPOCHLORITE BLEACHING

The twelve experimental fabrics categorized as Set 4 were scoured with soap and water and subjected to a hypochlorite bleaching procedure recommended by Badische-Anilin and Soda-Fabrick AG (4). The bleaching solution was made up as follows:

1.4 grams per liter available chlorine

5.0 grams per liter soda ash (sodium carbonate)

1.0 grams per liter Basophen wetting agent and detergent

A 10:1 ratio of bleach solution to fabric was used in the procedure and the fabric was allowed to stand in the solution at 20 to 25° C. for two hours. After the treatment time had elapsed the fabric was removed, rinsed at room temperature, and neutralized with an acetic acid sour and a pH meter to determine the neutral point. This set of fabrics was dried in accordance with the procedure described previously.

HYDROGEN PEROXIDE BLEACHING

The hydrogen peroxide bleaching procedure used on Set 5 of the fabrics was provided by E. I. Du Pont De Nemours and Company, Inc. (11), manufacturers of "Albone" Hydrogen Peroxide. An Atlas Launder-Ometer and the following proportions of chemicals were used in the pre-scouring and bleaching treatments. These proportions were based on 1.0 gram of fabric.

Scouring	Sodium Carbonate	.0696 gram
	Soap	.0606 gram
Bleaching	Sodium Silicate (42 Be', Water Glass)	.18 gram
	"Albone" Hydrogen Peroxide	.18 gram

For the scouring step each specimen was placed in a stainless steel container with a 25:1 ratio of scouring solution to fabric and processed for 30 minutes at 180-200^{0} F. in the Launder-Ometer. After this procedure the fabrics were rinsed thoroughly in clear water and neutralized with an acetic acid solution.

Immediately following scouring the fabrics were returned to stainless steel cylinders along with the required amount of bleaching solution shown above and processed in the Launder-Ometer for 45 minutes at the same temperature used in the scouring treatment. Fabrics were rinsed thoroughly with water at 120^{0} F., neutralized, and dried in accordance with the procedure used for the other treatments.

METHOD OF LAUNDERING

Each set of experimental fabrics was placed in a net in preparation for laundering. This procedure was followed as a precautionary measure in protecting the knitted fabrics from distortion during the 25 laundering periods.

All laundering was done in eight-pound loads in a Whirlpool automatic washer with a normal ten-minute cycle and a wash temperature of 140^{0} F. followed by a warm rinse. The washer was set for high agitation and spin speeds and a high water level. One-half cupful of Tide was used as the detergent for each wash load.

At the completion of each laundering period the fabrics were removed from the laundry net and dried in an eight-pound load at a medium temperature in a Whirlpool dryer. After each fifth laundering and drying period the fabrics were dampened, blocked to their original dimensions, and placed flat on a padded table top until dry.

EXPOSURE OF EXPERIMENTAL FABRICS TO LIGHT

In order to determine the effects of light upon the 12 experimental fabrics included in each of the five respective sets of specimens one specimen from each fabric was subjected to 80 hours of exposure in an Atlas Fade-Ometer. The general procedure as outlined in AATCC Standard Test Method 16A-1964 (1a) was followed in the exposure of these fabrics.

A 3.0 by 5.0 inch specimen was cut from each fabric with the wales of the knit in the lengthwise direction of the specimen. After careful preparation the specimens were attached to masks with a black background and mounted in specimen holders. The holders were in turn fastened to a supported cylindrical rack of the Fade-Ometer which held the specimens 10 inches from the carbon arc lamp and caused them to rotate constantly around the arc to provide uniform exposure. After each 20 hours of exposure the specimens were removed from the Fade-Ometer and evaluated spectrophotometrically with reference to their reflectance.

REFLECTOMETER MEASUREMENTS

The reflectance of the experimental fabrics after laundering was measured by means of a Hunter Multipurpose Reflectometer in accordance with selected sections of Tentative Test Method: AATCC 110-1964T (1b), and instructions supplied by Gardner Laboratory Incorporated (13).

A green filter was used for determining the reflectance of the experimental fabrics. Comparisons were made between the fabrics and a porcelain-enameled metal plaque with a reflectance equivalent to that of a magnesium oxide standard (86.2 per cent). Five measurements were made on eight thicknesses of each of the experimental fabrics initially and following five, 10, 15, 20, and 25 laundering periods. The five individual readings for each fabric at the six respective periods of evaluation were averaged and reported as the per cent reflectance of that particular fabric.

SPECTROPHOTOMETRIC MEASUREMENTS

The Beckman DU Spectrophotometer was used to evaluate the reflectance of the experimental fabrics initially and after 20, 40, 60 and 80 respective hours of exposure to light. Reflectance measurements were taken at wavelengths representative of the visual spectrum ranging from 450 to 850 millimicrons. A white, bleached, and desized Indianhead fabric having a reflectance of 91.4 per cent was used as the standard for these evaluations. A mean of the data obtained as a result of the 10 spectrophotometric measurements of each fabric was reported as the per cent reflectance for that fabric at each respective evaluation period.

BURSTING STRENGTH

Bursting strength evaluations were made on each of the experimental fabrics initially and following five, 10, 15, 20, and 25 laundering periods in accordance with the general procedure outlined in ASTM Designation: D 231-62, Section 11 (2). A Scott Tensile Tester equipped with a Model W-Ball Burst Attachment was used for these evaluations.

Five specimens 4.5 by 4.5 inches were cut on grain from each fabric at the six respective testing periods. The specimens were subjected to standard conditions of $70 \pm 2^{\circ}$ F. and 65 ± 2% relative humidity for at least four hours before being burst in the dry state.

Data were analyzed in terms of bursting strength in pounds per mean wales and courses. To make such an analysis possible counts were made both in the course and wale directions to allow for compensation for any dimensional change in the knit fabrics due to the laundering and drying procedures. An Alfred Suter yarn counter was used for these counts.

PRESENTATION AND DISCUSSION OF DATA

Findings relative to an analysis of the twelve experimental fabrics under consideration in this study are recorded in Tables I through XXXV in the Appendix and are presented as a basis for this discussion. Data are classified into the following five categories on the basis of the various treatments used for the removal of impurities from the fabrics: (a) greige fabrics, (b) fabrics scoured with soap and water, (c) fabrics scoured with caustic soda, (d) fabrics bleached with sodium hypochlorite, and (e) fabrics bleached with hydrogen peroxide.

The experimental fabrics were subjected to 80 hours of exposure to light and to 25 periods of laundering, and thereafter evaluated with reference to their reflectance. Data which resulted from light exposure appear in Tables I through XXV, whereas Tables XXVI through XXX are devoted to reflectance values attributed to the laundering procedure. The bursting strength determinations tabulated in Tables XXXI through XXXV were made only on the fabrics which were subjected to laundering.

Statistical analyses of the data were determined by means of the "t" test with color and grade of cotton and fabric treatment as the variables. A classification of the experimental fabrics basic to these comparisons is shown in the Plan of Procedure.

SPECTROPHOTOMETRIC EVALUATIONS OF EXPERIMENTAL FABRICS BEFORE AND AFTER EXPOSURE TO 80 HOURS OF SUNLIGHT

The twelve experimental fabrics constructed from Texas cottons of a variety of colors and grades were evaluated by means of the spectrophotometer with reference to the effects of light upon them. These evaluations were made in terms of per cent reflectance at 10 wavelengths ranging from 400 to 850 millimicrons, initially, and after 20, 40, 60, and 80 respective hours of exposure to light in the Fade-Ometer. The following deductions might be drawn from the statistical analyses of these data.

GREIGE FABRICS

Spectrophotometric comparisons of the experimental fabrics failed to reveal any significant differences between the reflectance values of the cotton with or without respect to grade before exposure to light. After light exposure, comparisons with respect to grade showed significant differences to have appeared in the Light Spot category. In these comparisons the reflectance of the Middling cotton surpassed that of the Strict Low Middling and the Low Middling grades with significant differences amounting to $P<0.001$ and $P<0.05$, respectively. The mean reflectance of the Low Middling grade was affected more by light exposure than was that of the Strict Low Middling ($P<0.01$). See Part A of Figure 2 for a diagram of these comparisons. After light exposure comparisons irrespective of grade again showed the reflectance of the Middling cotton to be superior to the two lower grades with differences amounting to $P<0.01$ and $P<0.05$, respectively.

When the greige fabrics were compared relative to color only one difference was noted before exposure to light. Comparison of the spectrophotometric measurements without regard to grade revealed that the three fabrics constructed of White cotton exhibited a reflectance superior to that of the fabrics from Tinge cotton ($P<0.05$).

Eighty hours of exposure to sunlight magnified the differences between the colors of the experimental cottons. Comparisons based on color with respect to grade showed that significant differences were evident in each of the grades. White performed better than Tinge in all three grades ($P<0.05$, $P<0.05$, $P<0.01$) and better than Light Spot ($P<0.001$) in the Strict Low Middling class. Light Spot proved to have better reflectance values than Tinge both in the Middling ($P<0.01$) and Low Middling ($P<0.05$) categories. See Parts A, B, and C of Figure 2 for illustrations of these relationships. Without regard to grade comparisons further emphasized the superiority of White cotton over the other three colors with the following differences: $P<0.001$ when compared to Tinge; $P<0.01$ in comparison with Spot; and $P<0.05$ in relation to Light Spot fabrics. The fabrics representative of Light Spot cotton were superior in reflectance to those cottons designated as being of the Tinge variety ($P<0.02$).

FABRICS SCOURED WITH SOAP AND WATER

Spectrophotometric measurements of the fabrics scoured with soap and water when compared with respect to grade showed no significant differences in mean reflectance before exposure to light. Exposure to 20-80 hours of sunlight brought out differences in mean reflectance values in the Light Spot and Spot groups when grade comparisons were made with respect to color. In both color categories, Middling excelled over Strict Low Middling ($P<0.001$). Low Middling cottons also had a significantly higher mean reflectance than did Strict Low Middling ($P<0.001$) in the Light Spot color group. See Part A of Figure 3. Comparisons irrespective of color further emphasized the superior performance of Middling ($P<0.001$) and Low Middling ($P<0.02$) over Strict Low Middling cotton after light exposure.

When intercomparisons pertaining to color were made before exposure to light, significant differences were found both with and without respect to grade. No differences existed between the various colors of cotton in the Middling and Strict Low Middling grades, when colors of the soap and water scoured fabrics were compared with respect to grade. However, in the Low Middling grade Light Spot had significantly higher mean reflectance values than did Tinge ($P<0.05$). Comparisons before exposure without respect to grade revealed that White and Light Spot fabrics were superior in reflectance to those from Tinge cotton ($P<0.01$ and $P<0.02$, respectively).

After exposure to light, significant differences appeared among the colors within all three grades of cotton. In the Middling grade, Light Spot significantly surpassed the mean reflectance of White and Tinge ($P<0.05$ and $P<0.01$). Within the Strict Low Middling cottons White surpassed the other three colors in mean reflectance with differences ranging from $P<0.01$ to $P<0.05$. Comparisons between colors in the Low Middling category revealed that White, Light Spot, and Spot excelled in mean reflectance values over Tinge ($P<0.01$, $P<0.01$, and $P<0.02$). Light Spot also proved to be superior to Spot ($P<0.01$).

Exposure to 80 hours of light resulted in widespread differences in reflectance of Tinge and the remaining three colors when compared irrespective of grade. White and Light Spot displayed values which were highly superior to those of Tinge ($P<0.001$), whereas Spot was superior to the darker cotton to a lesser degree ($P<0.05$).

FABRICS SCOURED WITH CAUSTIC SODA

Comparisons based on grade before exposure to light revealed that significant differences, both with and without respect to color, existed within the fabrics scoured with caustic soda. No significant differences in grade existed within the White, Spot, and Tinge categories, whereas Middling cotton proved to be superior in mean reflectance to Strict Low Middling ($P<0.02$) and Low Middling ($P<0.05$) in the Light Spot category. For comparisons between the grades, disregarding color, the only significant difference in mean reflectance emphasized the superiority of Middling over Low Middling cottons ($P<0.01$).

Exposure to 80 hours of sunlight resulted in significant differences between grades in all four color categories. Low Middling cottons were superior in reflectance values to the Strict Low Middling fabrics ($P<0.02$) in the White category. Strict Low Middling cottons were also surpassed in performance by Middling and Low Middling in the Light Spot group. Middling and Strict Low Middling performed in a superior manner in the Spot ($P<0.001$) and Tinge ($P<0.01$) color groups. Comparisons in the Tinge category further revealed that Middling fabrics were highly superior in mean reflectance values to the Low Middling cottons ($P<0.001$). Comparisons irrespective of color favored Middling cotton over the Strict Low Middling grade ($P<0.001$) as is evident in Figure 3, Part B.

When the caustic scoured fabrics were compared on the basis of color, the fabrics exhibited comparable reflectance values within grades before exposure to light with the exception of those fabrics in the Low Middling grade. White and Light Spot possessed reflectance values superior to the Tinge cotton ($P<0.02$ and $P<0.05$). White also excelled over Light Spot ($P<0.05$). Comparisons irrespective of grade before exposure, again revealed White and Light Spot to be superior in reflectance to Tinge ($P<0.001$ and $P<0.02$).

Evaluation of the caustic scoured fabrics after exposure to light on the basis of color showed that significant differences existed within all three grades of cotton. In the Middling category, White was surpassed by Light Spot, Spot, and Tinge ($P<0.001$, $P<0.001$, and $P<0.02$). The Strict Low Middling grade showed Spot to be superior to White, Light Spot, and Tinge ($P<0.01$, $P<0.001$, and $P>0.01$, respectively), and revealed the reflectance of White and Tinge to exceed that of Light Spot ($P<0.001$, $P<0.02$). Color comparisons within the Low Middling grade showed that White and Light Spot surpassed both Spot and Tinge ($P<0.001$). In color comparisons disregarding grade, White and Light Spot gave significantly better reflectance measurements than Tinge ($P<0.05$) following exposure to light. See Figure 3, Part C.

FABRICS BLEACHED WITH SODIUM HYPOCHLORITE

When the fabrics bleached with sodium hypochlorite, but not subjected to light, were compared on the basis of grade significant differences existed both with and without respect to color. Comparisons with respect to color showed that Middling was superior to Strict Low Middling ($P<0.01$) and Low Middling ($P<0.05$) in the Light Spot category. Within the Spot and Tinge classifications, Middling had a significantly higher mean reflectance than did Low Middling ($P<0.01$ and $P<0.05$). Grade comparisons irrespective of color favored Middling cottons over both Strict Low Middling and Middling ($P<0.02$ and $P>0.001$).

Exposure to 80 hours of light resulted in differences in grade performance in all four color categories. Within the White fabrics, Strict Low Middling was superior to Low Middling ($P<0.05$). Comparisons between grades in the Light Spot fabrics revealed the superiority of Middling over the two lower grades and Low Middling over the Strict Low Middling grade with differences amounting to $P<0.001$ in all instances. In the Spot category the reflectance of Middling and Strict Low Middling surpassed that of Low Middling ($P<0.001$). Middling also proved superior in the Tinge group having a higher mean reflectance than Strict Low Middling. Comparisons based on grade without regard to color revealed Middling to be superior in mean reflectance to Strict Low Middling and Low Middling cottons ($P<0.001$).

Comparisons between the fabrics in relation to the effect of color showed color to have an effect upon the reflectance of the Strict Low Middling and Low Middling cottons before exposure. White gave a superior performance to that of Light Spot ($P<0.001$) and Tinge ($P<0.02$), and Spot was superior in reflectance to Light Spot ($P<0.05$) in the Strict Low Middling group. Within the Low Middling comparisons, White surpassed Spot and Tinge ($P<0.01$ and $P<0.001$) and Light Spot excelled over Tinge ($P<0.01$). Color comparisons irrespective of grade revealed that White was superior to the remaining three colors with respect to mean reflectance values with differences significant at the following levels: $P<0.001$, $P<0.01$, and $P<0.001$, respectively. Spot was found to be significantly higher than Tinge in reflectance ($P<0.05$).

After 80 hours of exposure to sunlight, color comparisons based on grade revealed significant differences in reflectance within the Strict Low Middling and Low Middling categories. White, Spot, and Tinge were found to have significantly better reflectance values than Light Spot ($P<0.001$) in the Strict Low Middling group. Low Middling comparisons showed that White excelled over Light Spot ($P<0.05$) and Spot ($P<0.001$), while Light Spot also was superior to Spot ($P<0.05$). Figure 4, Part A shows these comparisons. In color comparisons, irrespective of grade, White proved to be superior to Light Spot ($P<0.001$) and Spot ($P<0.01$), and Light Spot had a mean reflectance significantly higher than that of Tinge ($P<0.02$).

FABRICS BLEACHED WITH HYDROGEN PEROXIDE

The fabrics bleached with hydrogen peroxide when compared with respect to grade within color before exposure to light showed significant differences to exist only in the Tinge color group. Middling and Strict Low Middling were significantly higher in mean reflectance than Low Middling ($P<0.01$). Grade comparisons irrespective of color showed that only one significant difference existed before the fabrics were exposed to light. The mean reflectance of Middling cotton surpassed that of the Low Middling fabrics ($P<0.01$).

Grade comparisons after light exposure showed that a wider range of differences existed in the mean reflectance values of the experimental fabrics. Comparisons of grades with respect to color revealed that differences then existed in three of the four color groups, Light Spot, Spot, and Tinge, as shown in Part B of Figure 4. Middling surpassed Low Middling in all three color groups ($P<0.001$, $P<0.001$, and $P<0.01$), and it also excelled over Strict Low Middling in the Light Spot comparisons ($P<0.001$). Strict Low Middling was superior to Low Middling within the Spot and Tinge categories ($P<0.01$). In comparisons irrespective of color Middling was found to be highly superior to both lower grades of cotton ($P<0.001$) and Strict Low Middling exhibited a more favorable reflectance value than did Low Middling ($P<0.01$).

When the hydrogen peroxide bleached fabrics were statistically compared on the basis of color before exposure to light significant differences with respect to grade were found to exist only in the Low Middling cottons. In these comparisons White and Light Spot were found to be superior in mean reflectance to Tinge ($P<0.001$ and $P<0.01$). Color comparisons irrespective of grade revealed no significant differences before exposure.

After 80 hours of exposure to light significant differences appeared in the color comparisons with respect to grade. In the Middling category Tinge performed in a manner superior to White ($P<0.05$). Within the Strict Low Middling group comparisons showed Tinge to be superior to White ($P<0.01$), Light Spot ($P<0.001$), and Spot ($P<0.02$). White excelled over Light Spot ($P<0.01$). Low Middling comparisons showed White to be superior to Light Spot ($P<0.02$) and Spot ($P<0.01$). Comparisons irrespective of grade revealed that Tinge and White had greater mean reflectance values than Light Spot ($P<0.05$), and that Tinge was superior to Spot ($P<0.01$).

COMPARISONS OF THE EXPERIMENTAL FABRICS WITH RESPECT TO SPECTROPHOTOMETRIC EVALUATIONS BEFORE AND AFTER EXPOSURE TO 80 HOURS OF SUNLIGHT

COMPARISONS ON THE BASIS OF COMPOSITE DATA

The methods of treatment to which the experimental fabrics were subjected were compared before and after exposure to 80 hours of sunlight on the basis of the pooled mean spectrophotometric evaluations for each group. These comparisons revealed that all four methods of removing impurities gave mean reflectance values which were significantly higher than those assessed the initial fabrics before and after exposure to light. Caustic scouring, sodium hypochlorite bleaching, and hydrogen peroxide bleaching gave superior results to those obtained from soap and water scouring ($P<0.001$). Sodium hypochlorite bleaching and hydrogen peroxide bleaching gave better results than did caustic soda in the removal of impurities. No significant differences existed between sodium hypochlorite and hydrogen peroxide bleaching before exposure, but after 80 hours of exposure, the mean reflectance of the fabrics bleached with sodium hypochlorite was superior to that attributed to fabrics bleached with hydrogen peroxide ($P<0.01$).

The effect of exposure to sunlight on each of the five groups of fabrics was determined by means of a comparison of the mean spectrophotometric evaluations assessed to each respective group before exposure with that taken after exposure. This treatment of data revealed that sunlight had a whitening effect upon specimens from all groups of fabrics except those which were bleached with hydrogen peroxide. In all instances the hydrogen peroxide treated fabrics were slightly darkened by light.

COMPARISONS ON THE BASIS OF GRADE, COLOR, AND TREATMENT

The spectrophotometric data were further analyzed with reference to the significant differences which appeared in the five groups of fabrics when reflectance values were compared with respect to the grade and color of cotton. The effect of grade and color was determined within each group of fabrics on a percentage basis using the relationship between the number of superior reflectance ratings by grade and by color of cotton and the number of comparisons used in the statistical analysis of the data. Thirty comparisons were used in the analysis of the effect of grade of cotton on each group of the fabrics, whereas 48 comparisons were necessary in determining the effect of color. The percentages which resulted from this analysis are shown in an organized manner in Summary A.

In the greige fabrics, Middling excelled over the lower grades in 13.3 per cent of the comparisons, while Low Middling made a much less impressive showing in surpassing the other two grades. The most prominent colors were White and Light Spot.

Grade of cotton made a difference in the comparisons which involved the soap and water scoured fabrics. The Middling grade possessed superior reflectance values in about one-tenth of the grade comparisons, while Low Middling showed superiority to a lesser extent. Color evaluations indicated that White, Light Spot, and Spot each performed in a significantly superior manner to that of Tinge.

An analysis of the caustic scoured fabrics revealed that grade affected reflectance in almost one-half of the comparisons. Middling fabrics showed definite superiority over the other two grades, and in a few of the comparisons, Strict Low Middling and Low Middling each showed superior reflectance values. The color comparisons revealed that indications of superiority were found to exist in all four color categories. White was most prominent, followed by Light Spot, Spot, and Tinge, respectively.

Grade again made a difference in reflectance in almost one-half of the comparisons within the sodium hypochlorite bleached fabrics. The Middling grade proved to have the most outstanding effect by greatly surpassing the other grades. Strict Low Middling gave better performance than did Low Middling, which excelled only in a small percentage of the comparisons. The color evaluations strongly indicated that color affected the reflectance values. In most of the comparisons, White gave significantly superior reflectance while Light Spot and Spot each excelled to a lesser degree. Tinge was also found to have a significant effect on reflectance behavior.

Middling fabrics exhibited twice as much influence as did Strict Low Middling in the grade comparisons involving hydrogen peroxide bleached fabrics. Color was again noted to affect the reflectance of the fabrics in that Tinge and White surpassed the other colors.

COMPARISONS ON THE BASIS OF GRADE AND COLOR BUT IRRESPECTIVE OF TREATMENT

Evaluations of the experimental fabrics with regard to color and grade but irrespective of treatment showed the overall effect which these properties had upon reflectance behavior before and after exposure to light. The effect of each factor was determined on a percentage basis using the relationship between the total number of significantly superior reflectance values for grade or for color and the total number of comparisons used in analyzing the data. The analysis of grade involved 150 comparisons, whereas 240 were used in evaluating color.

The comparisons with respect to grade revealed that Middling grade had a much more pronounced effect upon reflectance than did the other two grades in that it was found to have significantly better reflectance in 24.0 per cent of the comparisons. Strict Low Middling and Low Middling excelled in 5.3 and 4.0 per cent of the cases, respectively.

Color comparisons showed that White cottons possessed superior performance in 16.7 per cent of the total comparisons. The Light Spot, Spot, and Tinge fabrics each showed evidence of a significantly superior reflectance behavior in 8.3, 3.8, and 5.4 per cent, respectively, of the color comparisons.

In overall evaluations of the effect of grade and color upon reflectance, color was shown to be slightly more influential than was grade. Grade made a significant difference in 33.3 per cent of the total evaluations with respect to grade, whereas color made a significant difference in 34.2 per cent of the color evaluations.

SUMMARY A

Percentages of Significant Differences on the Basis of Grade, Color, and Treatment as Shown by Comparisons of Spectrophotometric Evaluations

Treatments	GRADE			COLOR			
	Middling	Strict Low Middling	Low Middling	White	Light Spot	Spot	Tinge
Greige	13.3	0.0	3.3	20.8	10.4	0.0	0.0
Soap and Water	10.0	0.0	6.6	12.5	12.5	4.2	0.0
Caustic Soda	30.0	6.6	6.6	14.6	12.5	8.3	4.2
Sodium Hypochlorite	40.0	6.6	3.3	22.9	4.2	4.2	6.2
Hydrogen Peroxide	26.6	13.3	39.9	12.5	2.1	2.1	16.7

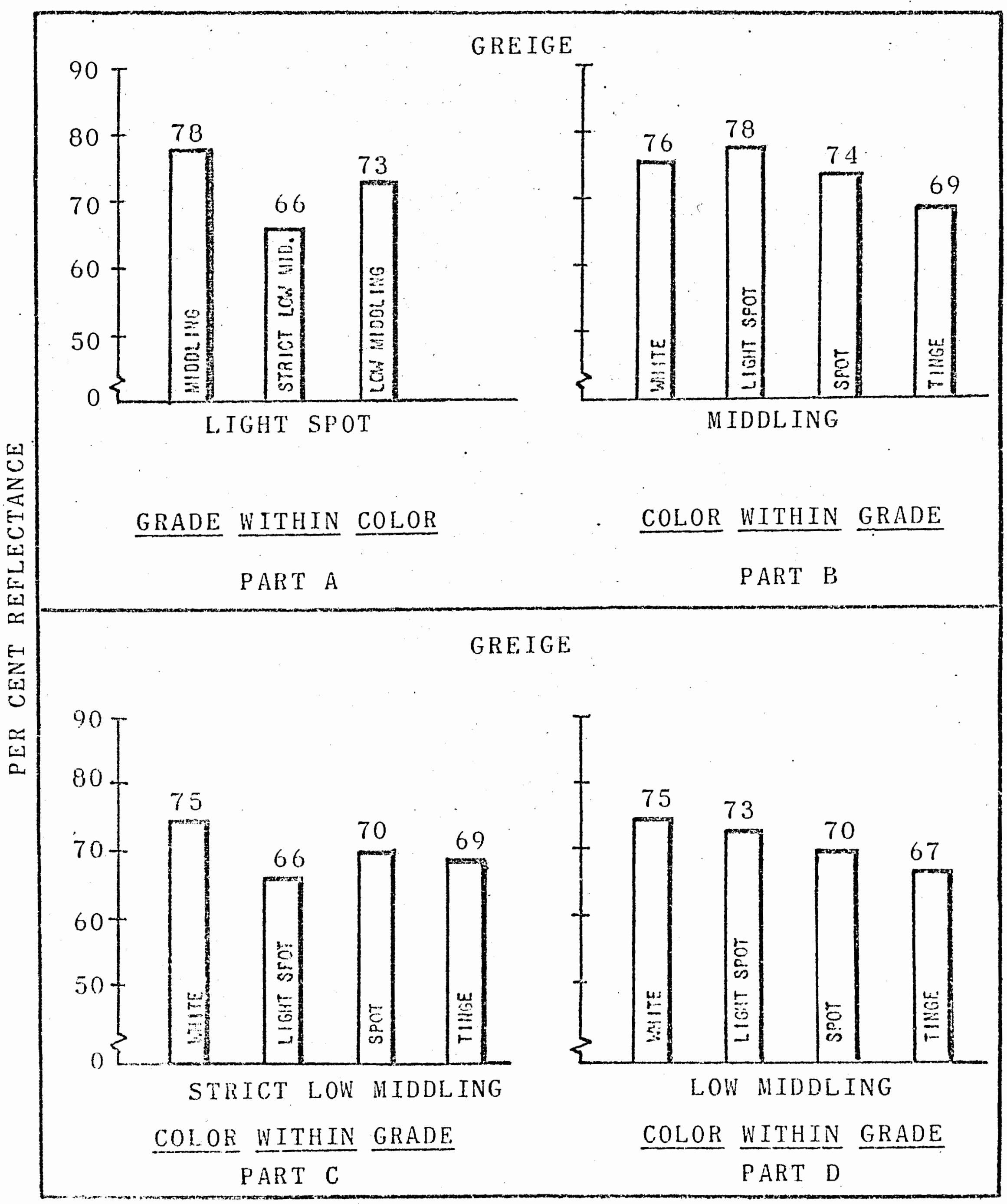

FIGURE 2

THE EFFECTS OF EXPOSURE TO SUNLIGHT UPON THE REFLECTANCE OF GREIGE FABRICS

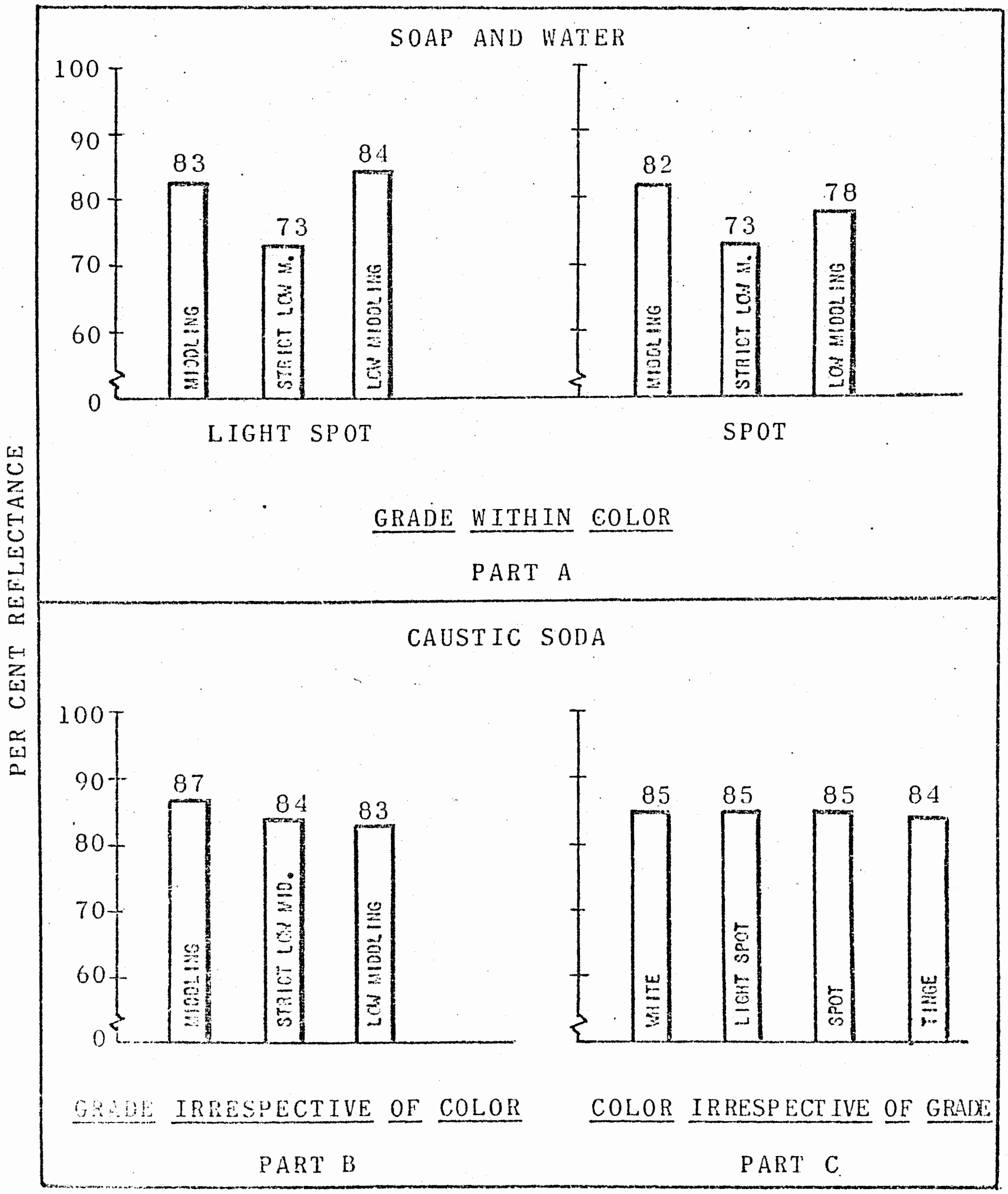

FIGURE 3

THE EFFECTS OF EXPOSURE TO SUNLIGHT UPON THE REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AND CAUSTIC SODA

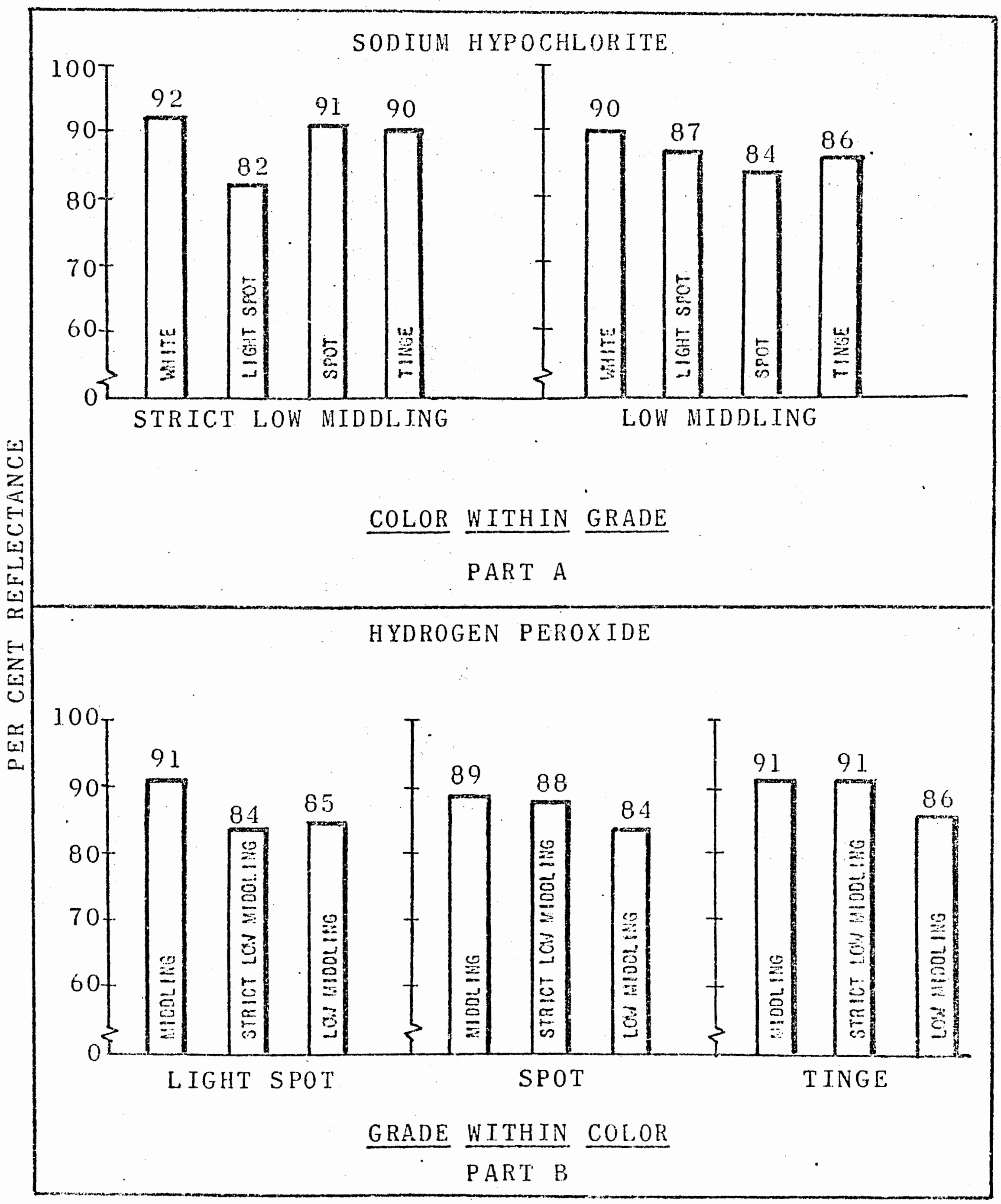

FIGURE 4

THE EFFECTS OF EXPOSURE TO SUNLIGHT UPON THE REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AND HYDROGEN PEROXIDE

MULTIPURPOSE REFLECTANCE EVALUATIONS OF EXPERIMENTAL FABRICS BEFORE AND AFTER 25 PERIODS OF LAUNDERING

The twelve experimental fabrics were evaluated by means of the Hunter Multipurpose Reflectometer with reference to the effect of laundering upon them. The evaluations were made in terms of per cent reflectance, with a green filter and a standard with a reflectance of 86.2 per cent, before laundering and after one, five, 10, 15, 20, and 25 laundering periods. These evaluations were pooled for each respective fabric and compared as the basis for the following discussion.

GREIGE FABRICS

Comparisons of the greige fabrics on the basis of mean reflectance values after 25 laundering periods with and without respect to grade and color produced differences only in two of the comparisons. When data from the four respective colors of cotton were pooled independently and considered irrespective of grade the fabrics constructed from White and Light Spot cotton exhibited superior reflectance values to those of the Tinge variety. Differences between these categories of cotton were significant at the one and five per cent levels, respectively.

FABRICS SCOURED WITH SOAP AND WATER

Reflectometric evaluations revealed that soap and water scouring in conjunction with the 25 laundering periods to which these fabrics were subjected had some influence upon the experimental cottons. The differences which were noticeable in the two instances as a result of comparisons made between the mean reflectance values of the initial fabrics after laundering were removed by soap and water scouring followed by laundering. Statistical comparisons of data representative of these fabrics failed to reveal any significant differences between the fabrics with respect to grade or color.

FABRICS SCOURED WITH CAUSTIC SODA

Comparisons of the data obtained from an evaluation of the reflectance of the fabrics scoured with caustic soda and laundered showed some superiority on the part of Middling and White cotton. In the Light Spot color category Middling cotton claimed a higher reflectance rating than Strict Low Middling ($P<0.02$). Differences did not exist between the reflectance measurements of the three grades in the remaining three colors of experimental cotton. A comparison of grades on the basis of pooled data for each respective grade without regard to color again showed the reflectance of Middling cotton to be superior to that of Strict Low Middling with a significant difference of $P<0.05$.

When colors were considered with respect to grade of cotton White fared better after caustic soda scouring and laundering than did Light Spot ($P<0.05$) in the Strict Low Middling grade only. An appreciable difference in performance was also noted in favor of White over Tinge ($P<0.01$) when the three grades in each color were pooled for comparative purposes.

FABRICS BLEACHED WITH SODIUM HYPOCHLORITE

Sodium hypochlorite bleaching followed by laundering tended in many instances to expand the differences between the experimental cottons with reference to color and grade. In the White and Tinge colors of cotton the three grades reacted to the bleaching and laundering treatments in much the same manner, but in the Light Spot and Spot colors differences between the grades pointed to the better bleaching properties of the Middling cotton. In the Light Spot cottons the reflectance of Middling was superior to that of Strict Low Middling ($P<0.05$) and to Low Middling ($P<0.001$), and Low Middling performed better than did the Strict Low Middling ($P<0.05$). In the Spot cottons Middling claimed a superior reflectance when compared with both of the lower grades of cotton with differences significant at the five per cent level in both comparisons. See Figure 5, Part A for an illustration of these differences.

The statistical comparisons which were necessary in determining the effect of hypochlorite bleaching and laundering upon the color of the experimental cottons revealed a number of significant differences between pairs. When the four respective colors were compared within each of the three grades of cotton color differences were noticeable only in the Strict Low Middling grade (Figure 5, Part B). White in this instance was accredited with a significantly higher reflectance value than was the Light Spot variety of cotton ($P<0.05$). Color comparisons irrespective of grade pointed to the superior rating of White over the three remaining colors in the study. Light Spot and Spot also claimed higher values than Tinge. Differences in these comparisons were highly significant ($P<0.001$) except in one case when White was found to surpass Light Spot only at the five per cent level. The results of these comparisons are shown in Figure 5, Part C.

FABRICS BLEACHED WITH HYDROGEN PEROXIDE

The effectiveness of hydrogen peroxide and laundering in removing impurities from the experimental fabrics was evidenced by the few differences which existed between the fabrics after these treatments had been applied. Of the 39 comparisons which were made on the basis of grade and color only five showed significant differences. Three of these cited the properties of Middling as being favorable over the remaining grades, whereas two comparisons supported White as the superior color.

Comparisons on the basis of grade within each color showed only one difference which appeared in the Light Spot cottons and confirmed the reflectance of Middling to be superior to that of Strict Low Middling ($P<0.05$). When all colors were pooled together within each grade for comparative purposes between the grades Middling was favored over Strict Low Middling ($P<0.05$) and Low Middling ($P<0.01$).

The only significant difference which was found to exist when reflectance data were compared on the basis of color within each grade of cotton was in the Strict Low Middling category. White was accredited with a higher reflectance than that of Light Spot ($P<0.05$). Comparisons based on color without regard to grade revealed that White was superior to Tinge ($P<0.05$).

COMPARISONS OF THE EXPERIMENTAL FABRICS WITH RESPECT TO REFLECTANCE EVALUATIONS BEFORE AND AFTER 25 PERIODS OF LAUNDERING

COMPARISONS ON THE BASIS OF COMPOSITE DATA

The effectiveness of the various treatments upon the experimental fabrics after 25 laundering periods was compared on the basis of the composite data for each treatment. The results of these comparisons showed that the mean reflectance of the untreated but laundered fabrics was much lower than the reflectance values which resulted from the four treatments in combination with laundering. These differences were highly superior ($P<0.001$) except in one case. The soap and water scoured fabrics were superior to the untreated fabrics at a lower level of probability ($P<0.01$).

Both sodium hypochlorite and hydrogen peroxide bleaching were more effective methods of removing impurities than were soap and water and caustic soda scouring. Sodium hypochlorite after laundering was found to give more satisfactory results than hydrogen peroxide.

COMPARISONS ON THE BASIS OF GRADE, COLOR, AND TREATMENT

Data were analyzed further with reference to significant differences which appeared in the five groups of fabrics when reflectance values were compared on the basis of grade and color. The effect of grade or color was determined in each general group of fabrics on a percentage basis by using the relationship between the number of superior reflectance ratings received by a grade or color of cotton and the number of comparisons used in the statistical analysis of the data. Fifteen comparisons were necessary for the analysis of the effect of grade, whereas 24 were required in determining the effect of color in each treatment category. These differences appear in Summary B.

In the greige fabrics no differences were noted between the grades of cotton, but there was a slight indication that White and Light Spot cotton performed better with reference to reflectance. In 4.1 per cent of the comparisons which were based on color each of these colors was superior to the two darker colors of cotton.

Although the mean reflectance values which resulted from the soap and water scouring followed by laundering were not as high as those produced by the three remaining methods used in the removal of impurities the grades and colors of the cottons were not determining factors in the performance of the experimental fabrics.

Among the comparisons involving fabrics scoured with caustic soda, Middling cotton performed better than did the other grades 13.3 per cent of the time. White cotton also performed in a superior manner to the other three colors in 8.2 per cent of the comparisons.

Evidence of the role of grade as related to reflectance in the sodium hypochlorite bleached and laundered fabrics was brought out in 39.9 per cent of the comparisons made in this area. Middling fabrics excelled in mean reflectance values in 33.3 per cent of the comparisons based on grade while Low Middling was better in 6.6 per cent of the cases. Color made a difference in reflectance in 24.8 per cent of the comparisons within the sodium hypochlorite bleached and laundered fabrics. Indications of superiority were found in the White, Light Spot, and Spot fabrics. In 16.6 per cent of these cases White gave better reflectance, while Light Spot and Spot were each superior 4.1 per cent of the time.

Middling cottons claimed superiority over the Strict Low Middling and Low Middling grades in 20.0 per cent of the comparisons related to grade in the hydrogen peroxide bleached and laundered fabrics. In 8.2 per cent of the comparisons White was the superior color.

COMPARISONS ON THE BASIS OF GRADE AND COLOR BUT IRRESPECTIVE OF TREATMENT

A summary of the frequency with which a particular grade or color received a superior rating for all of the treatments to which the experimental fabrics were subjected served as the basis for determining the overall effect of color and grade upon the reflectance of fabrics laundered 25 periods. The effect of color was determined on a percentage basis by using the relationship between the number of superior reflectance ratings received by a particular color and the 120 comparisons involving color in this part of the study. The 75 comparisons used in the comparisons of grade were instrumental in determining the effect of grade.

Comparisons revealed that Middling and Low Middling grades performed better with respect to reflectance than did the Strict Low Middling cottons. Middling fabrics were found to give reflectance values superior to those of the other grades in 13.3 per cent of the cases, and Low Middling showed superiority in 1.3 per cent of the comparisons.

Color comparisons showed White, Light Spot, and Spot fabrics to perform better with reference to reflectance values. White was superior in 7.5 per cent of the color comparisons, while Light Spot excelled in 1.6 per cent of the cases, and Spot showed superior reflectance ratings in 0.8 per cent of the evaluations.

In overall effect, grade had a greater effect on reflectance than did color. Grade showed evidence of a significant effect in 14.6 per cent of the grade comparisons, whereas color influenced reflectance values in only 9.9 per cent of the color comparisons.

SUMMARY B

Percentages of Significant Differences on the Basis of Grade, Color, and Treatment as Shown by Comparisons of Multipurpose Reflectance Evaluations

Treat-ments	GRADE			COLOR			
	Middling	Strict Low Middling	Low Middling	White	Light Spot	Spot	Tinge
Greige	0.0	0.0	0.0	4.2	4.2	0.0	0.0
Soap and Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caustic Soda	13.3	0.0	0.0	8.3	0.0	0.0	0.0
Sodium Hypo-chlorite	33.3	0.0	6.6	16.6	4.2	4.2	0.0
Hydrogen Peroxide	20.0	0.0	0.0	8.3	0.0	0.0	0.0

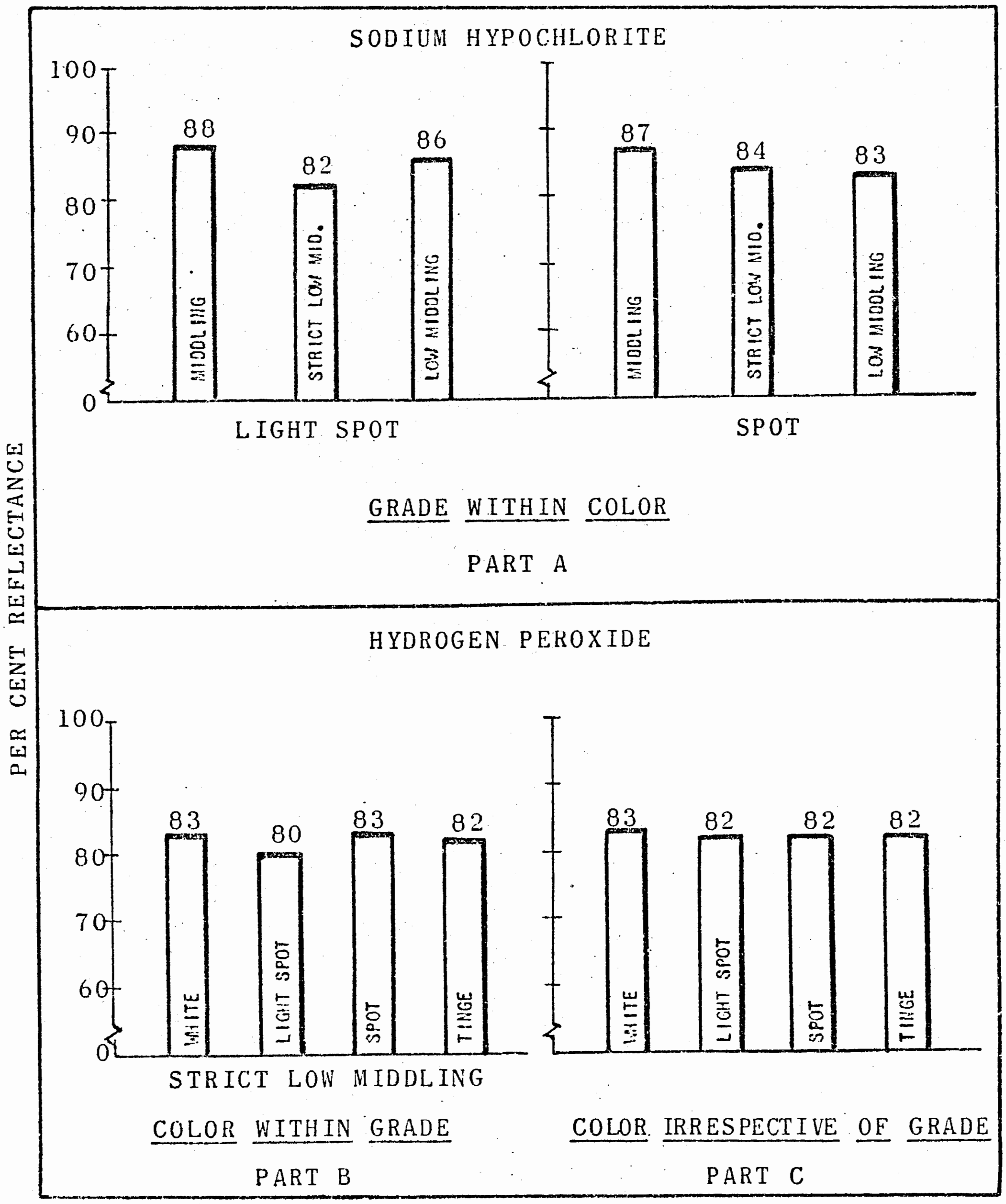

FIGURE 5

THE EFFECTS OF LAUNDERING UPON THE REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AND HYDROGEN PEROXIDE

BURSTING STRENGTH EVALUATIONS OF EXPERIMENTAL FABRICS BEFORE AND AFTER 25 PERIODS OF LAUNDERING

The experimental fabrics were subjected to a series of 25 laundering periods and tested initially and after every five laundering periods with reference to their bursting strength. The bursting strength values for each fabric were pooled and data were statistically compared on the basis of mean bursting strength values within each set of experimental fabrics. Comparisons included grade with respect to color, grade irrespective of color, color with respect to grade, and color irrespective of grade.

GREIGE FABRICS

The greige fabrics after 0-25 launderings, when statistically compared on the basis of grade with regard to color, showed no significant differences between the mean bursting strength values of the White fabrics. Comparisons within the Light Spot color group revealed that Strict Low Middling cottons were stronger than Middling cottons ($P<0.05$). In the Spot category, Middling and Strict Low Middling showed favorably over Low Middling cottons in mean bursting strength with significant proportions of $P<0.02$ and $P<0.01$, respectively. Strict Low Middling also excelled over Low Middling ($P<0.02$) in the Tinge comparisons. When compared by grade irrespective of color, Strict Low Middling was significantly stronger than both the Middling (P<0.05) and Low Middling grades (P<0.001).

Bursting strength values compared by color both with and without regard to grade produced a number of differences, all of which were significant at the two per cent level. Within the Middling grade of cotton two differences appeared one of which was favorable to White in comparison with Light Spot while the other pointed to the superior resistance of Light Spot over Spot. In the Low Middling category, White cottons gave a superior performance to that of Spot and Tinge fabrics. Color comparisons without respect to grade revealed that White fabrics were superior in mean bursting strength to Light Spot and Tinge cottons.

FABRICS SCOURED WITH SOAP AND WATER

Bursting strength comparisons within the fabrics scoured with soap and water revealed that this method of treatment had increased the differences among the fabrics. Significant differences appeared between grades within the Light Spot, Spot, and Tinge groups of fabrics as shown in Figure 6, Part A. Strict Low Middling performed in a superior manner to Middling and Low Middling in the Light Spot (P<0.01) and Spot (P<0.02) color groups. Low Middling was superior to Middling Light Spot (P<0.05) but inferior to Middling and Strict Low Middling within the Tinge fabrics.

Comparisons of grades irrespective of color again emphasized the performance of Strict Low Middling over Middling and Low Middling ($P<0.05$ and $P<0.001$). These comparisons also revealed that the resistance of Middling to bursting was better than that of Low Middling ($P<0.05$). When the fabrics were compared by color with regard to grade, several differences within the three grades were evident (Figure 6, Part B). In the Middling cottons, White, Spot, and Tinge were stronger than Light Spot with the same degree of superiority ($P<0.01$). Spot was superior to White and Tinge ($P<0.05$) in the Strict Low Middling grade, and in the Low Middling cottons both White ($P<0.001$) and Light Spot ($P<0.01$) were more resistant to bursting than was the Tinge. Color comparisons irrespective of grade also revealed White and Spot to be stronger than Tinge ($P<0.05$).

FABRICS SCOURED WITH CAUSTIC SODA

Bursting strength evaluations of the fabrics scoured with caustic soda revealed that definite patterns did not exist with reference to the manner in which the experimental fabrics performed. Comparisons of grade within color indicated a tendency for Strict Low Middling and Middling to react more favorably than did the Low Middling. In the Light Spot and Spot color groups the Strict Low Middling grade of cotton offered a more significant resistance to bursting than did Middling with differences of $P<0.01$ and $P<0.05$, respectively, and in the Spot and Tinge classifications both higher grades were superior to the Low Middling cotton as shown in Part A of Figure 7.

Comparisons based on grade also showed that the two higher grades of cotton, Middling and Strict Low Middling, were superior in bursting strength to Low Middling ($P<0.01$ and $P<0.001$) cotton when considered without respect to color.

Evaluations with respect to color within grade revealed White, Spot, and Tinge to be stronger than Light Spot within the Middling grade ($P<0.01$). Spot surpassed Light Spot ($P<0.05$) in the Strict Low Middling fabrics, and White, Light Spot, and Spot were significantly stronger than Tinge within the Low Middling class (Figure 7, Part B). Comparisons of color irrespective of grade showed White to be stronger than Light Spot ($P<0.05$) and Tinge ($P<0.02$). Spot also excelled over Tinge ($P<0.05$).

FABRICS BLEACHED WITH SODIUM HYPOCHLORITE

Bleaching with sodium hypochlorite tended to decrease the number of differences between the experimental fabrics from the number which occurred in the scoured fabrics. Comparisons with regard to grade, both with and without respect to color, showed Middling and Strict Low Middling to perform better in most instances than Low Middling with reference to bursting strength. These findings were evident in both the Spot and Tinge colors of cotton with differences ranging from probabilities of $P<0.02$ to $P<0.001$, and when all colors were pooled for comparative purposes under each respective grade as is shown in Figure 8, Part A.

Color differences with regard to grade occurred in the Middling category. Spot was found to have a better strength performance after bleaching than did Light Spot ($P<0.01$) and Tinge ($P<0.02$). Comparisons irrespective of grade again showed Spot to be superior to Tinge ($P<0.05$) (Figure 8, Part B). White exhibited higher strength values after bleaching than did Light Spot or Tinge ($P<0.05$ and $P<0.02$).

FABRICS BLEACHED WITH HYDROGEN PEROXIDE

The effect of hydrogen peroxide bleaching on the strength of the fabrics was indicated by fewer and less widely spread differences than was shown by the sodium hypochlorite bleaching method.

Comparisons of grade with respect to color revealed that Strict Low Middling was stronger than Middling ($P<0.02$) within the Light Spot color group. In the Spot and Tinge color categories, Middling and Strict Low Middling exhibited superior bleaching behavior to that of Low Middling with differences ranging from $P<0.05$ to $P<0.001$. This same performance pattern of Middling and Strict Low Middling excelling over Low Middling was shown by comparisons of grade irrespective of color and is illustrated in Figure 8, Part C.

Color comparisons with respect to grade magnified differences in strength within each grade. White ($P<0.05$), Spot ($P<0.02$), and Tinge ($P<0.05$) all were superior to Light Spot in the Middling category. White and Spot performed better than Tinge ($P<0.05$) in the Strict Low Middling cottons, and White, Light Spot, and Spot surpassed Tinge in the Low Middling fabrics. Comparisons irrespective of grade showed White to be stronger than Spot or Tinge ($P<0.05$ and $P<0.01$) and Spot to exceed Tinge ($P<0.01$) in bursting strength. See Figure 8, Part D.

COMPARISONS OF THE EXPERIMENTAL FABRICS WITH RESPECT TO BURSTING STRENGTH EVALUATIONS BEFORE AND AFTER 25 PERIODS OF LAUNDERING

COMPARISONS ON THE BASIS OF COMPOSITE DATA

The effect of various methods used in the removal of impurities upon the strength of the experimental fabrics was revealed through a comparison of composite data for each treatment. Before laundering the greige fabrics were significantly stronger than the fabrics scoured with caustic soda ($P<0.02$). Sodium hypochlorite bleaching gave higher bursting strength values than did either the soap and water scoured ($P<0.05$) or the caustic scoured ($P<0.01$) fabrics, and differences did not exist between the effects of the two types of bleach upon the bursting strength of the greige fabrics.

After 5-25 laundering periods caustic scoured, sodium hypochlorite bleached, and hydrogen peroxide bleached fabrics were significantly stronger than the greige fabrics ($P<0.001$). They also exhibited a greater strength than did the soap and water scoured fabrics with differences of $P<0.05$, $P<0.001$, and $P<0.01$ attributed to the respective treatments. Fabrics bleached with sodium hypochlorite excelled over caustic scoured and hydrogen peroxide bleached fabrics ($P<0.001$).

COMPARISONS ON THE BASIS OF GRADE, COLOR, AND TREATMENT

The bursting strength data from each of the five respective sets of experimental fabrics were analyzed on the basis of the frequency with which a particular grade or color of cotton received a superior rating in the 39 statistical comparisons involved in the treatment of data for each group of fabrics. This analysis is shown percentagewise in Summary C.

Data secured from the greige fabrics indicated that grade affected the bursting strength in 40.0 per cent of the comparisons. In 33.3 per cent of the comparisons Strict Low Middling showed outstanding performance while Middling cottons made favorable showings 6.7 per cent of the time. Color also seemed to be an indication of strength in that White fabrics were shown to possess superior strength in 20.8 per cent of the comparisons. Spot fabrics showed slight indications of superiority by surpassing the other colors in bursting strength in 4.2 per cent of the comparisons.

Grade and color had an even greater effect on the fabrics scoured with soap and water than on the greige fabrics. Strict Low Middling proved to be the most predominant grade according to superiority in strength by surpassing the other two grades 46.7 per cent of the time. Middling cotton showed excellence in 13.3 per cent of the comparisons, while Low Middling was superior in 6.7 per cent of the cases. Color proved to have less effect than grade upon the strength of the fabrics scoured with soap and water as was evidenced by a significant difference in 37.6 per cent of the relationships. Spot had the greatest effect, which was indicated by a better performance 16.7 per cent of the time. White proved to be superior in 12.5 per cent of the comparisons, and in 4.2 per cent of the cases Light Spot and Tinge each showed indications of superiority.

Grade affected the strength of the fabrics scoured with caustic soda in over half of the comparisons. Strict Low Middling possessed significantly higher strength values in 33.3 per cent of the comparisons, whereas Middling excelled in 20.0 per cent of the comparisons based on grade. Significant differences in strength were shown in 61.6 per cent of the color relationships. Of these, White and Spot each gave better performance 26.6 per cent of the time while in 4.2 per cent of the collations Light Spot and Tinge were each outstanding.

The fabrics bleached with sodium hypochlorite were affected by color and grade in a manner similar to the overall effect of each factor on the greige fabrics in that grade influenced stength in 40.0 per cent of the comparisons while color affected the performance in 20.8 per cent of the cases. Middling and Strict Low Middling each were superior 20.0 per cent of the time. Comparisons related to color showed Spot to excel in 12.5 per cent of the cases and White to surpass the other colors in 8.3 per cent of the relationships.

Comparisons with the hydrogen peroxide fabrics showed grade and color to affect strength in a pattern similar to that found for the caustic scoured fabrics. Strict Low Middling claimed superiority in 26.6 per cent of the cases while Middling made favorable showings in 20.0 per cent of the instances. Color had an impact upon the performance of the fabrics by affecting strength significantly in 55.8 per cent of the color comparisons. White and Spot were dominant in 20.8 per cent and 26.6 per cent of the cases, respectively. Light Spot and Tinge each affected strength significantly in 4.2 per cent of the collations.

COMPARISONS ON THE BASIS OF GRADE AND COLOR BUT IRRESPECTIVE OF TREATMENT

Evaluations of grade and color irrespective of treatment revealed the overall relationship of grade and color to the strength performance of the experimental fabrics. The effect of each factor was determined on a percentage basis by using the relationship between the number of superior bursting strength values of grade or color and the number of comparisons used in analyzing the data. The analysis of grade involved 75 comparisons, whereas 120 comparisons were used in evaluating the effect of color.

Among the comparisons involving grade, Strict Low Middling had a more pronounced effect upon fabric strength than did the other grades in 3.2 per cent of the collations. Middling fabrics performed in a superior manner 16.0 per cent of the time while Low Middling excelled in only 1.3 per cent of the total relationships.

White cotton performed in a superior manner to the other colors 15.3 per cent of the time. Spot made a significant difference in bursting strength in 13.3 per cent of the comparisons, whereas Light Spot and Tinge each surpassed the other colors in strength in only 2.5 per cent of the cases.

Overall observations revealed that grade affected the strength performance in a greater percentage of comparisons than did color. Grade statistically affected bursting strength in 49.3 per cent of the grade comparisons, and color affected strength in 34.1 per cent of the color relationships.

SUMMARY C

Percentages of Significant Differences on the Basis of Grade, Color, and Treatment as Shown by Comparisons of Bursting Strength Evaluations

Treatments	GRADE			COLOR			
	Middling	Strict Low Middling	Low Middling	White	Light Spot	Spot	Tinge
Greige	6.7	33.3	0.0	20.8	0.0	4.2	0.0
Soap and Water	13.3	46.7	6.7	12.5	4.2	16.7	4.2
Caustic Soda	20.0	33.3	0.0	16.7	4.2	16.7	4.2
Sodium Hypo-chlorite	20.0	20.0	0.0	8.3	0.0	12.5	0.0
Hydrogen Peroxide	20.0	26.6	0.0	20.8	4.2	16.7	4.2

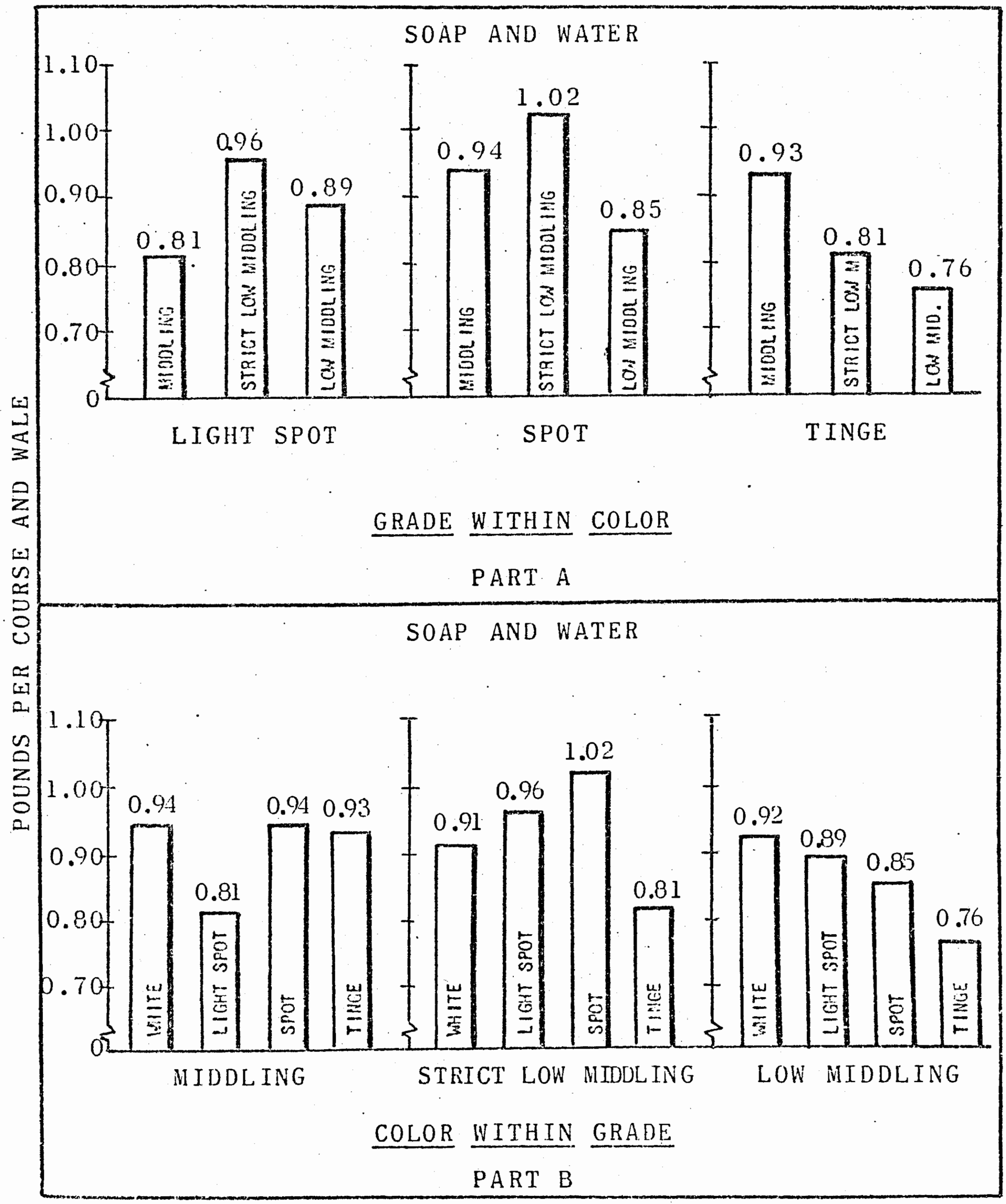

FIGURE 6

THE EFFECTS OF LAUNDERING UPON THE BURSTING STRENGTH OF FABRICS SCOURED WITH SOAP AND WATER

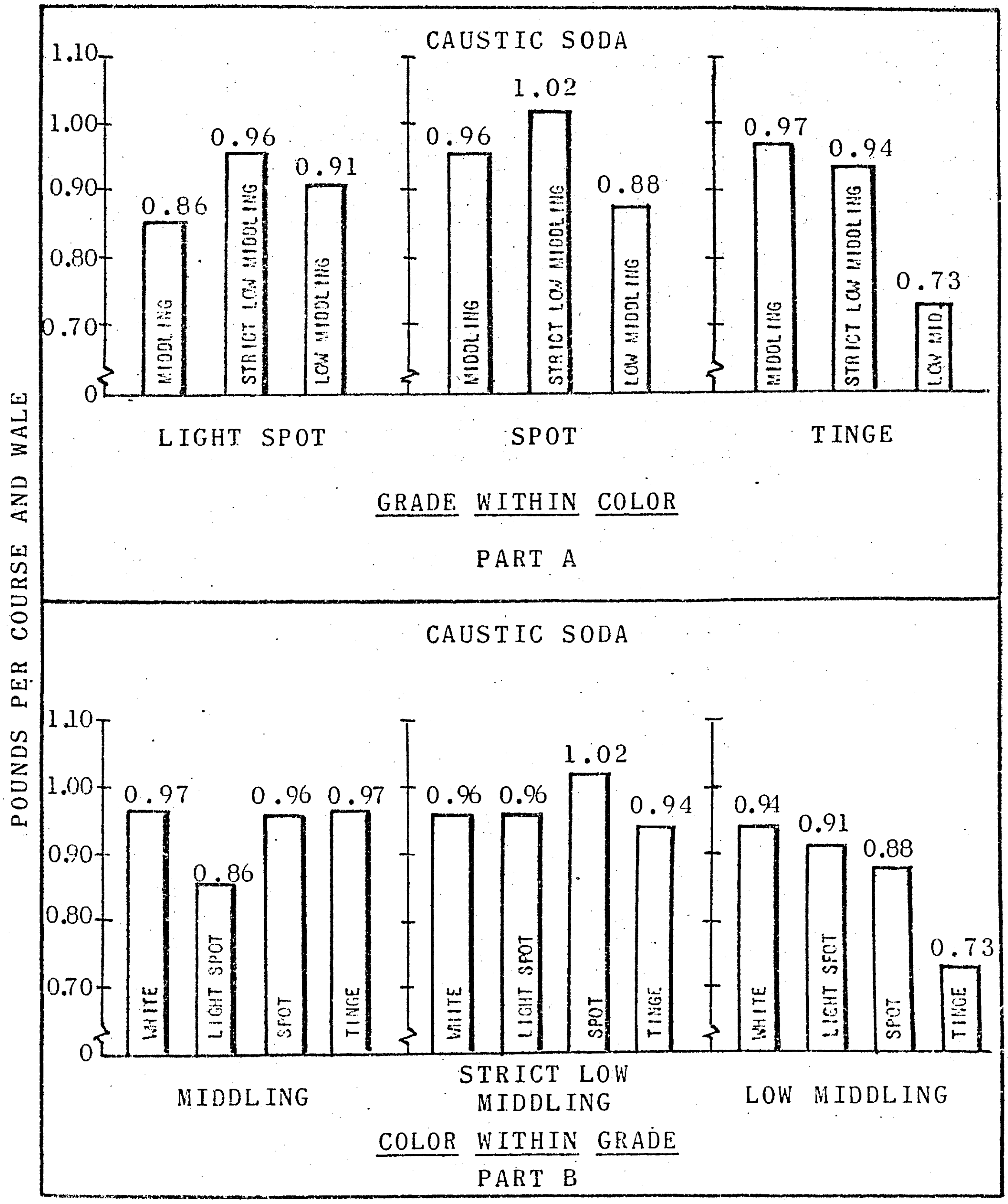

FIGURE 7

THE EFFECTS OF LAUNDERING UPON THE BURSTING STRENGTH OF FABRICS SCOURED WITH CAUSTIC SODA

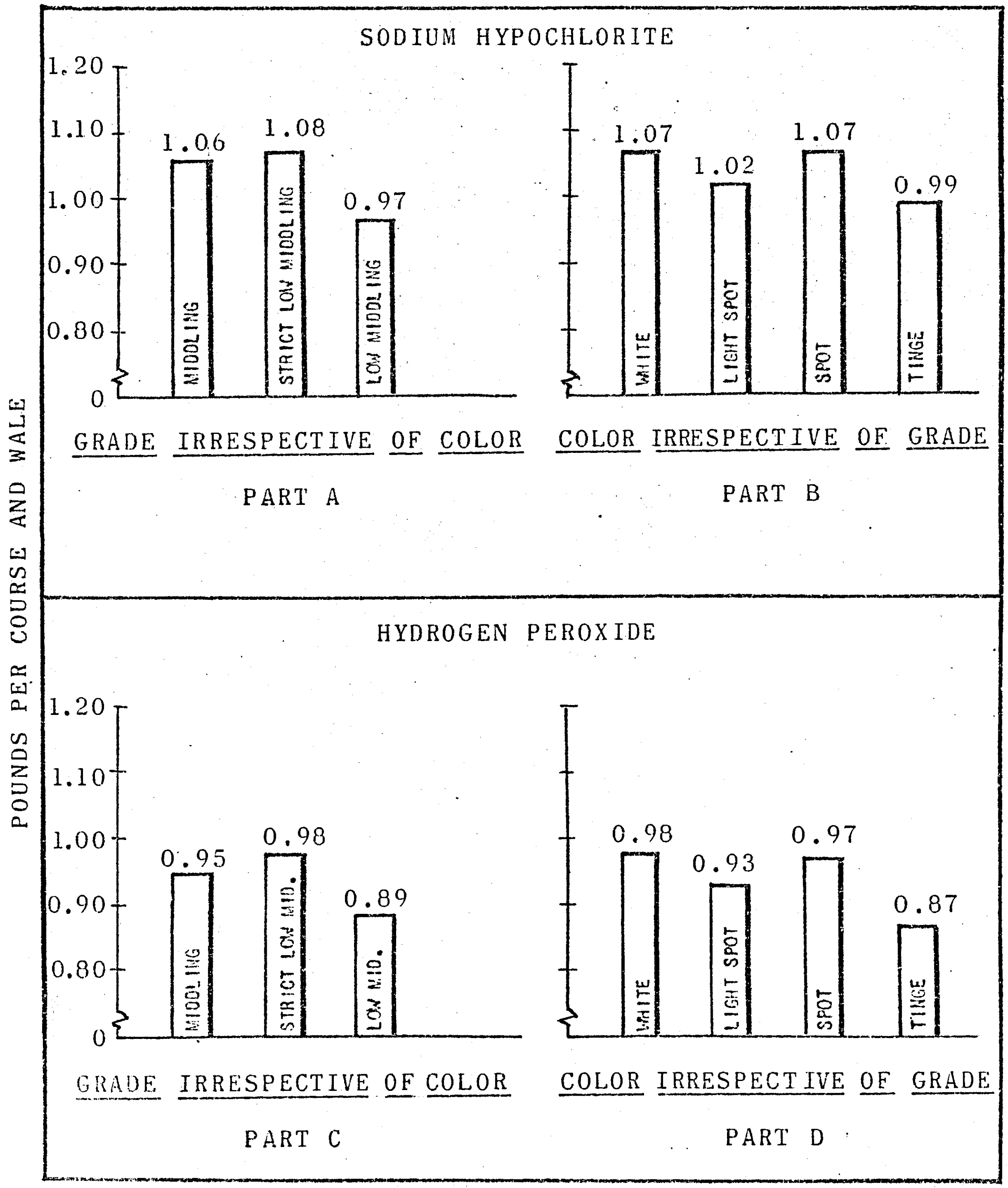

FIGURE 8

THE EFFECTS OF LAUNDERING UPON THE BURSTING STRENGTH OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AND HYDROGEN PEROXIDE

S U M M A R Y

This study was undertaken in an attempt to measure the effects of grade and color upon the scouring and bleaching properties of Texas cotton. Twelve fabrics knitted from four colors of Middling, Strict Low Middling, and Low Middling grades of cotton served as experimental fabrics for the study. Each of the 12 fabrics was divided into five sets, one of which was tested in the greige state, and the remaining four sets were either subjected to soap and water scouring, caustic soda scouring, sodium hypochlorite bleaching, or hydrogen peroxide bleaching. They were exposed to laundering and to sunlight and analyzed with reference to their performance.

In order to determine the effects of light upon the 12 experimental fabrics included in each of the five respective sets one specimen from each fabric was subjected to 80 hours of exposure in an Atlas Fade-Ometer. After each 20 hours of exposure the specimens were removed from the Fade-Ometer and evaluated spectrophotometrically with reference to their reflectance.

As a basis for determining the effects of laundering upon the experimental fabrics in each of the five sets,

specimens were subjected to 25 laundering periods in a Whirlpool home washer at a temperature of 140^{o} F. At the completion of each laundering period, the fabrics were dried in a Whirlpool dryer and evaluated as to their reflectance and bursting strength initially and following every five laundering periods.

SPECTROPHOTOMETRIC EVALUATIONS

Spectrophotometric comparisons based on the methods of treatment to which the experimental fabrics were subjected showed the efficiency of the treatments with reference to their removal of impurities. Before exposure to light all of the scouring and bleaching methods improved the reflectance values of the fabrics significantly over those of the greige fabrics. Caustic scouring and hypochlorite and hydrogen peroxide bleaching improved the performance of the cottons above that provided by the soap and water scouring. Both types of bleaching yielded products with reflectance values superior to those of the fabrics scoured with caustic soda. Differences between the methods of bleaching failed to appear in the comparisons.

After exposure to light, comparisons of spectrophotometric values revealed the same behavior trend as was evident before exposure with one exception. The sodium hypochlorite bleached fabrics performed better than did those bleached with hydrogen peroxide which became slightly darker after exposure to light.

Data were pooled to include the reflectance values of the five sets of fabrics on the basis of grade before and after exposure to 80 hours of sunlight and ranked according to the number of instances of superiority. In 38 of the 150 comparisons Middling cotton had a far greater effect upon the reflectance behavior of the experimental fabrics than did the two lower grades of cotton. Strict Low Middling and Low Middling excelled in eight and six comparisons, respectively.

The reflectance of White cotton surpassed that of the remaining three colors in 40 of the 240 comparisons required in the analysis of the spectrophotometric data on the basis of color. Light Spot ranked second with only one-half as many instances of superiority as had been accredited to White. Spot ranked third with 13 instances of superiority, and Tinge was found to have the least influence upon the reflectance performance of the fabrics.

MULTIPURPOSE REFLECTANCE EVALUATIONS

The effectiveness of the various treatments upon the experimental fabrics after laundering was analyzed by means of the Hunter Multipurpose Reflectometer. The results of the comparisons of these data showed that the mean reflectance values of the greige fabrics were much lower than those attributed to each of the other sets of fabrics after laundering. Soap and water scouring gave better reflectance values than those which were recorded for the greige fabrics. Both sodium hypochlorite and hydrogen peroxide bleaching were more effective methods of removing impurities than were the two scouring methods, but sodium hypochlorite after laundering was found to give more satisfactory results than hydrogen peroxide.

When the reflectance data from the entire study were pooled and compared with reference to the grade of cotton the results were favorable to the Middling grade. In 10 of the 75 comparisons Middling cotton exhibited superior values to those of the two lower grades of cotton. Low Middling, in second place, showed very little influence with a significantly higher reflectance in only one grade comparison. The Strict Low Middling grade had no significantly important effect upon the performance of the fabrics.

From the standpoint of color which involved 120 comparisons White ranked first by being superior in nine of the comparisons. Light Spot, Spot, and Tinge ranked second, third, and fourth, respectively, with reference to their superiority in these reflectance comparisons.

BURSTING STRENGTH EVALUATIONS

The effect of various methods which were used in the removal of impurities from the experimental fabrics upon the strength of these fabrics was revealed through a comparison of the composite data for each treatment. Before laundering the greige fabrics were significantly stronger than those scoured with caustic soda; sodium hypochlorite bleaching gave higher bursting strength values than did either soap and water or caustic soda scouring methods; and no differences were found between the effectiveness of the two bleaching methods.

After laundering, comparisons showed that both types of bleaching and caustic scouring produced bursting strength values which were superior to those of the greige and the soap and water scoured fabrics. The sodium hypochlorite bleached fabrics excelled over those which were caustic scoured and hydrogen peroxide bleached.

Comparisons of data for the purpose of determining the effect of the grade of cotton upon the strength performance of the fabrics revealed a superior performance for the Strict Low Middling cotton in 24 of the 75 required comparisons. Middling cotton ranked second in these comparisons with only 12 superior ratings. The Low Middling cotton performed in a favorable manner only in one instance.

Composite data from 120 color comparisons inclusive of all treatments following 0-25 launderings revealed that all four colors of cotton affected the bursting strength performance of the fabrics. White proved to rank first in importance by excelling in 19 comparisons. Light Spot, in second place, made a slightly less impressive showing by surpassing the performance of the other colors in 16 cases. Spot and Tinge both ranked third with each having only three significant differences to their credit.

As a means of providing a final summary of the findings of this study data were pooled and compared on the basis of color and grade but irrespective of method of treatment to which the fabrics were subjected and the procedures which were used in the collection of data. From these data the following system of ranking was developed on the basis of the total number of times a grade or color of cotton received a superior rating in the 300 grade and 480 color comparisons required in the study:

Rank	Grade	Instances of Superiority	Rank	Color	Instances of Superiority
I	Middling	58	I	White	68
II	Strict Low Middling	32	II	Spot	26
III	Low Middling	8	III	Light Spot	25
			IV	Tinge	16

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A P P E N D I X

TABLE I

PER CENT REFLECTANCE OF INITIAL FABRICS AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	42	50	56	67	71	77	80	82	84	83	69
2	46	54	65	70	73	78	81	82	86	86	72
3	50	53	64	72	75	77	81	81	81	81	72
4	45	54	62	67	75	79	80	80	82	83	71
5	36	44	52	59	66	72	76	79	80	81	64
6	45	54	60	67	72	75	77	79	81	82	69
7	37	47	52	62	68	75	79	80	83	83	67
8	34	41	50	58	67	76	81	85	86	87	67
9	42	48	53	61	69	73	76	79	82	83	67
10	33	40	46	58	66	72	76	81	83	82	64
11	31	39	44	57	64	72	78	83	83	85	64
12	30	37	45	51	57	64	73	76	78	80	59

TABLE II

PER CENT REFLECTANCE OF INITIAL FABRICS AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 20 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	51	52	64	72	76	80	81	83	83	84	73
2	60	61	69	73	78	79	82	81	82	82	75
3	57	62	69	73	75	78	79	79	80	80	73
4	55	61	68	74	78	81	82	83	84	84	75
5	42	48	54	59	68	71	74	75	75	75	64
6	54	59	66	71	75	78	80	80	81	83	73
7	48	55	61	69	77	81	83	85	86	85	73
8	45	47	57	65	73	79	82	84	85	86	70
9	47	55	59	65	71	75	76	78	80	79	68
10	39	45	52	59	67	74	79	81	83	88	67
11	39	44	51	59	68	76	81	84	86	88	68
12	33	40	49	56	63	70	74	79	80	81	62

TABLE III

PER CENT REFLECTANCE OF INITIAL FABRICS AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 40 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	55	60	67	74	78	81	83	84	85	89	76
2	58	63	72	71	73	75	79	79	78	80	73
3	57	63	69	72	76	79	79	80	80	85	74
4	63	67	69	73	79	81	84	85	85	85	77
5	45	51	60	64	71	72	75	75	76	76	66
6	57	59	70	73	78	79	79	81	81	82	74
7	50	58	60	68	78	79	83	83	85	87	73
8	47	50	59	64	74	81	81	84	84	84	71
9	52	57	62	67	73	75	74	77	78	78	69
10	39	48	53	64	68	78	79	82	81	81	67
11	41	47	53	60	69	78	80	81	83	85	67
12	43	48	54	61	69	73	76	79	79	81	66

TABLE IV

PER CENT REFLECTANCE OF INITIAL FABRICS AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 60 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	60	64	71	75	82	83	85	86	84	86	78
2	65	70	70	78	80	83	84	84	85	87	79
3	64	69	73	78	79	81	83	83	83	84	78
4	63	69	74	78	83	85	84	86	88	86	80
5	46	51	58	64	70	74	76	78	78	80	68
6	55	62	66	71	76	76	77	78	80	79	72
7	54	60	66	73	75	79	84	84	85	85	74
8	45	51	57	65	72	77	80	82	83	84	70
9	51	57	61	67	72	76	78	78	80	79	70
10	45	50	56	66	72	79	81	84	86	87	71
11	43	49	57	64	70	78	83	84	84	88	70
12	46	52	59	63	73	76	81	84	85	84	70

TABLE V

PER CENT REFLECTANCE OF INITIAL FABRICS AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 80 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	56	60	67	70	77	82	84	84	83	91	75
2	59	64	69	75	75	77	78	78	78	80	73
3	60	63	70	74	75	79	80	81	82	84	75
4	59	64	71	76	77	84	85	86	88	88	78
5	46	54	58	64	69	74	75	79	79	78	68
6	56	62	67	73	76	79	79	80	81	81	73
7	56	61	64	72	77	82	85	85	87	87	76
8	46	52	58	64	71	80	81	82	84	85	70
9	51	57	62	68	71	77	82	78	78	82	71
10	43	49	54	63	72	78	82	83	86	86	70
11	43	47	55	63	71	77	83	85	85	86	70
12	43	51	57	62	70	77	79	81	84	85	69

TABLE VI

PER CENT REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	52	60	65	72	80	80	84	83	86	88	75
2	54	59	66	71	76	80	83	83	84	86	74
3	59	65	71	76	79	82	85	86	88	89	78
4	57	65	71	75	79	82	85	84	85	88	77
5	44	50	55	62	68	73	77	80	82	84	68
6	60	66	71	76	79	83	85	87	88	89	78
7	50	55	62	69	74	82	86	88	91	91	75
8	39	45	51	58	64	72	78	81	84	88	66
9	52	58	68	68	71	76	79	81	83	84	72
10	39	43	50	59	67	73	80	83	86	89	67
11	35	39	45	54	60	72	78	82	84	87	64
12	39	44	51	57	63	69	76	79	84	85	65

TABLE VII

PER CENT REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 20 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	54	63	69	74	79	83	85	86	85	85	76
2	58	66	72	76	80	81	82	85	85	85	77
3	56	65	71	76	78	79	84	84	84	86	76
4	63	73	79	82	87	87	89	89	87	88	82
5	48	56	57	69	76	77	81	80	82	83	71
6	63	72	76	82	85	83	86	87	88	87	81
7	56	65	71	78	79	85	85	87	88	88	78
8	42	49	57	62	70	76	80	83	84	86	69
9	55	63	67	72	78	81	83	83	83	85	75
10	47	54	60	67	75	81	86	89	89	90	74
11	41	49	55	63	71	79	82	85	86	88	70
12	43	50	57	62	67	69	74	79	83	86	67

TABLE VIII

PER CENT REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 40 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	60	69	75	79	82	85	88	87	87	87	80
2	62	67	76	81	83	86	86	85	89	87	80
3	63	70	76	80	83	85	86	87	88	88	81
4	68	76	79	83	86	87	88	87	88	88	83
5	51	57	63	71	76	80	83	84	86	86	74
6	66	72	78	82	84	92	90	92	94	94	84
7	61	69	74	80	85	88	90	91	92	91	82
8	48	54	59	67	75	84	84	87	88	90	74
9	62	63	71	76	80	84	85	86	87	88	78
10	52	58	64	71	77	85	87	89	89	91	76
11	45	51	58	68	73	80	85	84	86	88	72
12	45	51	57	65	74	78	82	85	89	88	71

T A B L E I X

PER CENT REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 60 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	64	70	77	81	84	87	86	87	88	87	81
2	65	72	78	79	84	86	88	87	90	90	82
3	65	70	76	80	83	88	89	89	91	92	82
4	69	77	83	84	88	89	90	90	90	91	85
5	52	59	65	71	76	79	84	83	86	87	74
6	72	88	86	85	85	87	89	89	89	90	86
7	64	71	77	82	85	88	92	92	93	93	84
8	48	54	63	71	75	84	84	87	90	90	75
9	60	66	70	75	82	85	85	86	89	90	79
10	55	61	65	73	79	84	86	90	90	90	77
11	51	58	64	70	77	85	88	89	91	93	77
12	46	53	64	65	74	78	82	84	87	88	72

TABLE X

PER CENT REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 80 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	62	69	71	78	82	85	85	87	88	89	80
2	64	69	74	79	82	84	86	86	87	86	80
3	64	70	77	78	82	85	86	87	87	88	80
4	79	74	81	80	81	86	86	86	88	88	83
5	52	60	64	70	75	80	80	83	83	84	73
6	67	73	78	80	87	80	82	85	87	88	81
7	64	70	75	80	84	87	90	90	91	92	82
8	50	56	61	68	74	80	84	85	87	86	73
9	61	68	72	77	82	86	87	88	87	86	80
10	57	64	69	76	83	86	90	91	92	92	80
11	52	57	63	70	77	84	87	88	89	89	76
12	52	56	61	69	75	80	82	86	88	89	74

TABLE XI

PER CENT REFLECTANCE OF FABRICS SCOURED WITH CAUSTIC SODA AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	66	69	75	80	84	85	87	86	87	88	81
2	67	73	77	80	84	83	85	87	85	86	81
3	69	71	77	80	82	86	86	86	88	87	81
4	73	77	79	84	88	87	89	89	90	90	85
5	55	63	64	71	78	78	80	82	84	85	74
6	66	71	73	78	80	82	83	83	83	83	78
7	68	71	75	79	84	86	85	88	88	91	82
8	63	67	72	77	84	85	86	88	88	90	80
9	51	57	62	68	72	77	79	81	83	86	72
10	56	63	68	74	77	80	84	86	86	88	76
11	57	59	66	70	69	75	79	83	83	84	72
12	51	55	66	63	69	73	77	78	80	82	70

TABLE XII

PER CENT REFLECTANCE OF FABRICS SCOURED WITH CAUSTIC SODA AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 20 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	77	81	81	84	84	85	85	86	86	88	84
2	78	81	81	85	87	86	86	90	87	86	85
3	80	81	83	84	85	86	87	86	86	86	84
4	85	87	85	89	90	91	91	92	91	92	89
5	66	69	72	76	77	80	83	81	81	80	76
6	76	80	85	84	87	89	89	89	89	88	86
7	78	81	84	86	89	89	90	90	90	90	87
8	72	77	80	83	85	88	89	90	89	91	84
9	59	63	70	72	77	80	80	82	83	84	75
10	75	77	81	85	87	88	90	90	90	90	85
11	68	74	76	80	83	87	86	86	86	89	82
12	65	69	72	76	78	81	83	84	84	85	78

TABLE XIII

PER CENT REFLECTANCE OF FABRICS SCOURED WITH CAUSTIC SODA AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 40 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	79	81	84	85	86	87	87	86	87	86	85
2	81	83	84	85	86	86	87	87	87	87	85
3	80	83	85	86	89	87	89	88	88	88	86
4	77	78	82	88	84	85	85	86	88	91	84
5	73	74	80	80	84	84	85	84	85	85	81
6	80	81	84	87	89	91	91	91	93	93	88
7	81	85	87	89	90	91	91	92	91	91	89
8	76	82	83	88	88	89	91	92	93	93	88
9	64	67	70	76	82	81	83	85	86	85	78
10	80	83	85	87	91	91	93	90	91	94	89
11	71	75	80	83	87	87	89	88	87	88	84
12	67	71	74	77	81	81	82	83	83	83	78

TABLE XIV

PER CENT REFLECTANCE OF FABRICS SCOURED WITH CAUSTIC SODA AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 60 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	83	83	83	87	91	89	90	91	90	87	87
2	75	80	82	84	85	86	86	87	90	92	85
3	81	82	85	86	89	87	87	88	89	88	86
4	85	84	86	89	91	91	91	92	92	90	89
5	74	74	79	80	86	88	85	84	85	87	82
6	78	84	86	88	88	93	90	91	91	90	88
7	81	85	87	90	90	91	91	91	93	92	89
8	81	81	84	88	88	95	95	95	95	96	90
9	66	71	75	82	84	85	87	87	89	89	81
10	83	88	80	90	91	93	93	93	93	92	91
11	72	77	80	86	85	87	87	88	89	90	84
12	69	73	78	79	82	85	86	86	88	87	81

TABLE XV

PER CENT REFLECTANCE OF FABRICS SCOURED WITH CAUSTIC SODA AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 80 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	80	82	84	85	85	87	87	86	87	86	85
2	72	74	78	79	80	82	82	83	86	87	80
3	81	84	84	85	87	87	87	88	89	88	86
4	84	87	88	88	90	90	90	90	91	91	89
5	73	78	80	79	80	83	82	83	84	85	81
6	80	83	85	86	87	89	88	91	90	91	87
7	83	86	88	86	89	91	91	91	93	94	89
8	83	80	85	86	86	90	90	91	92	93	88
9	67	70	73	79	81	83	83	85	87	87	80
10	77	83	83	85	84	88	88	88	89	89	85
11	72	77	81	86	88	89	88	89	90	89	85
12	69	74	75	79	80	82	85	85	85	85	80

TABLE XVI

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	82	90	94	93	93	95	94	94	96	95	93
2	84	89	93	94	92	93	94	95	94	95	92
3	81	88	91	89	91	92	91	91	93	92	90
4	82	90	91	92	90	93	92	93	93	96	91
5	68	75	80	80	78	87	85	89	89	90	82
6	79	87	88	88	87	89	90	89	89	89	88
7	81	90	91	92	92	93	93	93	93	93	91
8	74	82	88	90	90	93	94	94	94	94	89
9	72	79	82	84	84	87	88	87	89	87	84
10	72	81	87	88	89	92	91	92	93	94	88
11	71	79	84	87	87	90	90	89	90	89	86
12	67	72	79	80	82	85	83	84	86	86	80

TABLE XVII

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 20 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	78	88	90	93	93	96	96	96	95	96	92
2	76	88	88	93	90	98	95	95	96	98	92
3	74	84	90	90	90	93	94	94	96	98	90
4	80	87	89	96	94	94	95	96	96	96	92
5	62	73	77	82	84	88	88	90	88	88	82
6	74	86	86	88	89	90	90	92	93	90	88
7	80	87	91	93	95	96	99	98	99	98	94
8	68	80	85	90	92	96	98	96	96	98	90
9	68	76	80	84	86	89	89	89	90	90	84
10	70	80	86	90	90	96	98	97	96	98	90
11	68	79	80	88	88	95	94	96	96	96	88
12	66	78	83	90	86	92	91	94	94	94	87

TABLE XVIII

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 40 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	78	83	89	91	95	95	96	96	97	98	92
2	88	87	90	91	92	95	93	94	94	93	92
3	80	86	89	90	92	94	93	92	93	92	90
4	79	86	88	90	88	93	93	93	93	92	90
5	67	74	77	80	82	86	87	87	88	87	82
6	76	82	83	88	88	90	91	92	92	94	88
7	71	80	82	84	85	91	94	94	93	94	87
8	72	83	89	91	94	96	99	99	99	99	92
9	71	78	80	86	89	88	90	91	92	93	86
10	75	83	89	91	94	96	98	97	97	97	92
11	74	78	83	88	88	92	95	96	96	97	89
12	69	78	83	85	87	89	91	90	90	92	85

TABLE XIX

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 60 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	84	84	90	92	95	96	99	98	99	96	93
2	82	87	94	92	91	95	95	96	96	95	92
3	82	83	88	90	88	92	93	90	89	91	89
4	84	88	92	92	91	95	95	94	95	95	92
5	69	76	79	82	84	86	87	87	88	90	83
6	79	82	86	88	90	91	92	93	94	95	89
7	79	84	88	90	91	95	94	94	95	95	90
8	80	86	89	90	94	92	95	94	94	94	91
9	70	76	80	82	85	86	88	88	89	88	83
10	79	86	90	91	92	96	97	96	99	96	92
11	74	83	87	89	90	93	95	96	99	98	90
12	73	80	88	88	91	93	95	96	95	95	89

T A B L E X X

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 80 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	79	84	86	89	92	92	93	94	94	94	90
2	83	86	88	90	90	91	94	93	94	96	90
3	82	85	87	88	88	91	91	92	92	92	89
4	87	90	94	94	93	96	95	96	97	96	94
5	69	76	77	81	81	85	85	86	86	85	81
6	76	81	82	84	83	85	88	87	88	87	84
7	79	82	85	88	90	92	93	92	93	93	89
8	77	83	86	89	90	93	94	95	95	96	90
9	70	76	79	83	86	88	89	88	89	91	84
10	81	86	90	91	93	97	96	97	96	98	92
11	79	80	89	90	91	95	97	96	97	99	91
12	75	77	82	85	84	89	89	91	91	90	85

TABLE XXI

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	78	86	89	90	92	91	91	89	92	93	89
2	76	85	84	87	88	90	90	90	91	93	87
3	81	87	90	93	94	93	93	94	94	94	91
4	80	88	90	92	92	93	92	94	93	94	91
5	74	81	85	88	88	91	90	90	92	92	87
6	76	83	86	87	89	91	91	92	93	93	88
7	78	85	90	92	96	95	96	97	98	98	92
8	81	82	88	90	88	92	93	93	93	93	89
9	68	74	78	81	89	91	93	94	94	94	86
10	75	82	88	93	98	99	98	95	96	95	92
11	74	89	90	92	90	95	98	99	95	95	92
12	61	68	73	77	78	83	84	82	85	87	78

TABLE XXII

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 20 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	75	83	89	87	88	92	90	90	93	91	88
2	77	85	83	88	88	91	92	92	90	91	88
3	75	83	89	90	87	85	91	92	91	92	88
4	80	86	90	90	89	93	92	93	92	91	90
5	68	78	78	83	81	87	86	85	88	88	82
6	72	79	85	91	87	92	89	92	91	90	87
7	76	84	88	91	92	92	91	94	91	96	90
8	76	88	87	89	91	92	94	95	93	95	90
9	67	78	88	85	85	87	93	93	96	94	87
10	78	86	90	89	91	92	93	95	95	98	91
11	71	81	84	87	90	91	93	92	92	93	87
12	61	76	83	86	89	90	90	94	97	94	86

TABLE XXIII

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 40 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	77	85	88	90	89	91	92	91	93	92	89
2	76	81	87	87	87	89	88	90	89	89	86
3	74	81	85	87	88	90	90	90	90	90	87
4	81	88	86	90	90	92	92	92	93	94	90
5	63	80	83	84	86	88	89	89	89	89	84
6	72	80	84	85	85	88	88	90	90	90	85
7	79	85	86	88	88	90	91	90	90	90	88
8	73	79	84	85	88	90	90	91	90	91	86
9	66	72	73	80	83	86	86	87	88	86	81
10	73	75	90	92	94	96	96	96	96	97	92
11	75	83	90	91	91	98	95	98	98	95	91
12	72	80	85	88	89	91	92	93	93	93	88

TABLE XXIV

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 60 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	82	86	86	88	88	90	92	92	92	93	89
2	80	85	86	87	90	90	90	91	91	93	88
3	85	86	90	86	88	91	90	92	94	92	89
4	82	87	89	90	91	92	94	95	94	94	91
5	77	79	82	86	85	88	87	89	88	89	85
6	75	77	81	83	85	86	87	86	87	89	84
7	80	83	87	88	89	88	89	91	92	91	88
8	81	89	88	90	91	90	90	91	91	90	89
9	70	75	80	83	85	90	90	90	91	92	85
10	80	91	89	94	93	95	96	96	97	97	93
11	77	88	90	92	93	98	95	95	95	96	92
12	70	77	81	84	85	86	90	90	90	90	84

TABLE XXV

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AS MEASURED SPECTROPHOTOMETRICALLY AT DESIGNATED WAVELENGTHS AFTER 80 HOURS OF EXPOSURE IN A FADE-OMETER

Lot Number	WAVELENGTHS IN MILLIMICRONS										
	400	450	500	550	600	650	700	750	800	850	Average
1	80	84	86	89	89	89	91	91	91	91	88
2	79	81	82	85	87	89	90	90	90	91	86
3	79	84	84	87	87	88	90	91	92	92	87
4	83	86	89	89	91	91	93	93	94	92	91
5	77	80	84	83	84	86	88	88	88	88	85
6	76	80	82	85	85	88	88	88	87	88	85
7	84	86	90	90	92	92	94	94	94	95	91
8	75	81	85	84	86	88	87	90	90	88	86
9	69	74	77	81	83	86	86	87	86	87	82
10	77	83	87	88	87	90	92	92	92	92	88
11	82	86	88	93	92	97	97	98	97	98	93
12	73	78	81	85	86	88	88	90	91	92	85

TABLE XXVI

PER CENT REFLECTANCE OF INITIAL FABRICS AS MEASURED BY THE MULTIPURPOSE REFLECTOMETER AFTER DESIGNATED PERIODS OF LAUNDERING

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	61.7	65.5	67.6	82.2	82.7	83.2
2	63.5	68.2	70.7	83.5	82.5	82.8
3	62.2	67.1	70.2	82.3	82.4	82.8
4	63.4	67.0	69.8	83.4	83.5	83.6
5	53.9	55.1	57.8	76.7	77.9	87.8
6	59.4	66.6	69.2	82.2	82.4	82.1
7	56.0	56.7	59.8	79.8	80.1	80.1
8	52.2	49.2	52.2	76.7	77.3	78.1
9	53.5	62.2	65.3	81.5	81.4	82.9
10	49.9	47.2	48.5	77.4	79.2	79.0
11	48.2	44.4	46.2	72.5	73.9	74.0
12	48.8	48.3	49.7	77.1	78.8	78.7
Average	56.0	58.1	60.6	79.6	79.3	73.6

TABLE XXVII

PER CENT REFLECTANCE OF FABRICS SCOURED WITH SOAP AND WATER AS MEASURED BY THE MULTIPURPOSE REFLECTOMETER AFTER DESIGNATED PERIODS OF LAUNDERING

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	66.0	67.8	81.2	85.8	85.7	87.0
2	67.8	69.4	82.9	86.2	85.2	86.4
3	67.3	69.5	81.4	86.4	85.1	85.9
4	70.0	68.5	82.4	86.3	85.8	86.6
5	55.0	57.5	76.6	83.0	82.9	83.4
6	67.4	69.2	81.4	84.5	85.0	85.3
7	61.4	58.2	75.4	85.6	84.5	86.0
8	50.4	51.6	71.2	82.4	84.2	83.8
9	62.0	64.5	80.5	83.8	84.8	85.0
10	51.9	45.5	75.3	85.4	85.0	84.9
11	49.4	45.8	73.2	84.7	84.6	84.4
12	49.0	49.6	75.7	84.8	84.9	85.4
Average	59.8	60.6	78.1	84.9	84.8	85.3

TABLE XXVIII

PER CENT REFLECTANCE OF FABRICS SCOURED WITH CAUSTIC SODA AS MEASURED BY THE MULTIPURPOSE REFLECTOMETER AFTER DESIGNATED PERIODS OF LAUNDERING

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	72.3	79.9	82.8	83.2	85.0	85.4
2	71.8	80.3	83.4	83.8	84.5	85.1
3	72.4	79.6	82.2	82.2	84.0	84.1
4	74.6	82.3	83.6	84.4	84.9	85.9
5	60.2	69.3	73.7	76.4	77.8	78.3
6	71.6	80.2	82.8	82.8	84.3	84.3
7	71.4	80.4	82.8	84.1	84.8	86.1
8	64.0	72.1	77.5	79.4	81.2	81.8
9	60.6	72.8	77.1	79.5	79.8	80.5
10	65.8	73.2	78.5	80.9	82.4	82.8
11	63.5	67.8	77.3	80.1	81.9	83.4
12	59.6	69.3	75.0	78.8	80.0	81.2
Average	67.3	75.6	79.7	81.3	82.6	83.2

TABLE XXIX

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AS MEASURED BY THE MULTIPURPOSE REFLECTOMETER AFTER DESIGNATED PERIODS OF LAUNDERING

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	85.8	87.2	88.7	87.7	87.9	86.4
2	86.8	86.3	88.0	87.7	87.5	86.9
3	84.8	85.5	87.3	87.0	86.6	85.4
4	86.6	87.5	88.7	88.3	88.4	87.8
5	77.6	81.3	82.3	83.3	84.0	83.3
6	82.0	84.6	86.6	86.8	86.0	87.0
7	83.8	86.3	87.6	86.9	87.7	87.2
8	80.8	82.6	85.0	84.5	85.9	85.8
9	78.3	82.5	84.5	84.8	84.8	84.5
10	78.0	79.2	81.2	82.2	83.0	83.0
11	72.3	75.6	79.1	81.1	80.7	81.0
12	78.6	80.5	82.8	83.7	83.8	83.8
Average	81.3	83.2	85.2	85.3	85.5	85.2

TABLE XXX

PER CENT REFLECTANCE OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AS MEASURED BY THE MULTIPURPOSE REFLECTOMETER AFTER DESIGNATED PERIODS OF LAUNDERING

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	82.0	83.2	83.0	83.4	84.0	86.2
2	81.8	82.8	82.3	82.5	82.4	85.8
3	81.5	83.0	82.0	82.6	83.0	86.9
4	82.6	84.0	82.2	83.7	83.4	88.2
5	77.2	79.2	80.0	79.7	80.2	84.4
6	79.2	81.5	82.9	80.6	83.0	85.8
7	82.4	82.8	81.8	82.7	83.8	87.2
8	80.3	81.6	80.9	81.6	83.2	87.2
9	73.5	79.8	80.3	80.9	78.2	85.4
10	81.3	81.4	81.2	81.0	83.5	86.6
11	79.8	80.6	80.6	80.3	84.3	86.9
12	77.3	78.8	78.6	78.9	82.1	85.4
Average	79.9	81.6	81.3	81.5	82.6	86.3

TABLE XXXI

BURSTING STRENGTH OF INITIAL FABRICS AFTER DESIGNATED LAUNDERING PERIODS (POUNDS PER WALE AND COURSE)

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	1.06	0.95	0.94	0.92	0.85	0.91
2	1.04	0.94	0.95	0.93	0.86	0.88
3	1.13	0.94	0.90	1.00	0.90	0.90
4	0.81	0.92	0.81	0.80	0.75	0.63
5	1.12	0.95	1.00	0.89	0.83	0.86
6	0.94	0.88	0.85	0.80	0.92	0.79
7	1.21	1.02	0.92	0.92	0.97	0.87
8	1.14	0.96	1.08	1.03	0.92	0.91
9	0.93	0.73	0.82	0.75	0.80	0.69
10	0.78	0.97	0.89	0.86	0.90	0.78
11	1.08	0.92	1.00	0.93	0.95	0.82
12	0.94	0.72	0.80	0.82	0.73	0.62
Average	1.02	0.91	0.91	0.89	0.87	0.81

TABLE XXXII

BURSTING STRENGTH OF FABRICS SCOURED WITH SOAP AND WATER AFTER DESIGNATED LAUNDERING PERIODS (POUNDS PER WALE AND COURSE)

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	0.91	0.95	0.98	0.99	0.94	0.86
2	0.94	0.97	0.92	0.83	0.88	0.93
3	0.93	0.92	0.99	0.92	0.89	0.89
4	0.85	0.80	0.69	0.79	0.87	0.87
5	1.00	0.93	0.94	0.95	1.00	0.95
6	0.92	0.89	0.90	0.84	0.94	0.86
7	0.92	0.88	0.96	0.97	0.95	0.94
8	0.96	0.95	0.97	1.09	1.13	1.02
9	0.86	0.67	0.98	0.87	0.86	0.84
10	0.96	0.89	0.88	0.97	0.96	0.93
11	1.03	0.90	0.84	0.88	0.91	0.91
12	0.82	0.73	0.75	0.83	0.74	0.67
Average	0.92	0.87	0.90	0.91	0.92	0.89

TABLE XXXIII

BURSTING STRENGTH OF FABRICS SCOURED WITH CAUSTIC SODA AFTER DESIGNATED LAUNDERING PERIODS

(POUNDS PER WALE AND COURSE)

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	0.89	0.98	1.04	0.96	1.03	0.94
2	0.91	1.04	1.00	0.91	1.03	0.90
3	0.89	0.92	0.99	0.97	0.94	0.93
4	0.88	0.90	0.92	0.82	0.85	0.80
5	0.98	0.99	0.99	0.95	0.93	0.94
6	0.79	0.92	0.97	0.91	0.99	0.90
7	0.94	0.93	1.00	0.94	0.98	0.97
8	0.96	1.02	1.06	1.06	1.02	0.99
9	0.82	0.94	0.83	1.00	0.86	0.85
10	0.93	0.98	1.00	1.00	0.92	0.96
11	0.90	0.90	1.10	0.99	0.93	0.80
12	0.76	0.67	0.80	0.75	0.74	0.67
Average	0.89	0.93	0.98	0.94	0.94	0.89

TABLE XXXIV

BURSTING STRENGTH OF FABRICS BLEACHED WITH SODIUM HYPOCHLORITE AFTER DESIGNATED LAUNDERING PERIODS

(POUNDS PER WALE AND COURSE)

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	1.03	0.96	1.14	1.06	1.14	1.12
2	0.95	1.08	1.00	0.98	1.09	1.19
3	1.06	1.11	1.00	1.02	1.08	1.19
4	1.01	0.89	0.96	0.90	1.08	1.01
5	1.03	1.02	0.99	1.08	1.11	1.09
6	0.96	1.07	0.94	1.08	1.00	1.07
7	1.13	1.26	1.11	1.11	1.15	1.27
8	1.06	1.06	1.05	1.14	1.24	1.25
9	0.90	0.96	0.86	0.83	1.05	0.85
10	1.06	1.00	1.00	0.88	1.02	1.14
11	0.89	1.06	1.00	1.11	1.07	1.20
12	0.85	1.00	0.84	0.79	0.90	0.91
Average	0.99	1.04	0.99	1.00	1.08	1.11

TABLE XXXV

BURSTING STRENGTH OF FABRICS BLEACHED WITH HYDROGEN PEROXIDE AFTER DESIGNATED LAUNDERING PERIODS

(POUNDS PER WALE AND COURSE)

Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	0.90	1.04	0.99	1.01	0.97	0.95
2	0.91	1.01	1.03	1.03	1.02	1.00
3	1.06	0.86	0.98	0.95	0.90	0.97
4	0.93	0.89	0.98	0.80	0.81	0.81
5	0.99	0.91	1.02	0.99	0.98	0.98
6	0.95	0.91	0.95	0.97	0.95	0.92
7	1.03	0.99	1.07	0.96	0.99	0.90
8	1.05	0.92	1.06	1.13	1.05	0.99
9	0.94	0.79	0.89	0.92	0.97	0.92
10	0.92	1.00	0.95	1.00	0.95	0.99
11	0.94	0.88	0.97	0.93	1.00	0.87
12	0.76	0.76	0.90	0.75	0.70	0.72
Average	0.95	0.91	0.98	0.95	0.94	0.92