THE ACCEPTANCE AND RETENTION OF VAT AND DIRECT DYES BY TEXAS COTTON

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

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We hereby recommend that the dissertation prepared under our supervision by Mary McComic Faulkinberry entitled "The Acceptance and Retention of Vat and Direct Dyes by Texas Cotton"

be accepted as fulfilling this part of the requirements for the Degree of Doctor of Philosophy.

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I N T R O D U C T I O N

The study reported in this dissertation was undertaken for the purpose of determining the effects of color and grade upon the dyeing properties of knitted fabrics constructed from 12 types of Texas cotton.

For many years the production of cotton has been extremely important to the state of Texas, since one-third of the cotton grown in the United States is produced annually in this state. The Texas cotton industry is representative of big business. It provides employment for 235,000 regular or seasonal workers with an annual payroll of approximately 322 million dollars.

The increased production of spotted or discolored cotton has threatened the economy of the industry during the last decade. This has been brought about, to a certain extent, by an attempt on the part of the cotton grower to lower production costs through mechanization. Since mechanization does not permit the harvesting of cotton as it opens, the fiber, in many cases, is unduly exposed to rain, wind, and dirt. These conditions along with pesticides, defoliants,

insects, soil, and mechanical harvesting all tend to cause variations in the color of the cotton fiber.

With the appearance of these variations in the color, a new system of grading has become necessary for cotton. In 1958, light spotted, spotted, tinged, and yellow stained cottons were added as new classifications and placed in price categories from two to six cents per pound lower than the white cotton of the same grade.

The economic effects of the production of discolored or spotted cottons has made it necessary to utilize these lower grades. This cannot be realized to the fullest extent without additional basic information concerning the performance of these cottons. Most of the dyers and finishers of cotton fabrics are aware of the fact that there are variations in the dyeing properties of cotton fibers, and that any change which alters the cellulose fiber also will alter the affinity of the fiber for dyestuff.

Extensive research has been undertaken, especially in the Textile Research Laboratories of Texas Woman's University, to determine the effect of grade upon the consistency of dyeing; but efforts to measure the degree to which the natural color of the fiber effects dyeing are limited. Therefore, this study has been undertaken with the following objectives.

OBJECTIVES OF THE STUDY

1. To secure 12 lots of Texas cotton representative of a variety of colors and grades.
2. To have these 12 lots of cotton knitted into fabric.
3. To subject a portion of each fabric to a scouring process followed by peroxide bleaching.
4. To dye a bleached and unbleached specimen of each fabric with 10 respective vat dyes selected from those advertised as being suitable for cotton.
5. To dye a bleached and unbleached specimen of each fabric with direct dyes of comparable hue and value to the vat dyes.
6. To launder one group of each of the dyed samples at 160° F. in the Launder-Ometer for the equivalent of 25 launderings.
7. To subject one group of each of the dyed samples to the Fade-Ometer for 80 hours of exposure.
8. To evaluate the specimens for color loss at specified intervals with the Beckman Spectrophotometer.
9. To analyze the data of the study statistically.

REVIEW OF LITERATURE

Because of the peculiar structure of cotton, many irregularities affect the form and color of the fiber. According to Crockett and Hilton (1), the growing cotton is coated with an oily wax which is composed of vegetable fat and resins. As the cotton matures, the film of oily wax solidifies and gives cotton a hard resinous coat. Any condition which interferes with the development of this coat causes an inferior product. These authors state that variations in the fiber may occur in cotton even under normal growing conditions. During a normal season, the strain of cotton, the climate, the season and the locality may affect the cotton fiber. In addition, abnormal variations in the development of the wall may exist, and result in immature cotton. Such variations include diseases, bad season, and imperfect building of the walls.

The immature cottons resulting from these variations are manufactured into products which appear to contain knots, or dead fibers, called "neps". When compared to mature fibers, these yarns are inferior in appearance and strength. The reflectance characteristics are altered by the "neps" which appear as white spots in the goods after dyeing. Also,

the dead cotton swells, but does not dissolve, in cuprammonium hydroxide; it does not react normally with other reagents. Hartsuch (2) stated, "If the interior layers of cotton do not develop properly and are incompletely formed during growth, the fiber will appear as a thin-walled ribbon with no twist. This so-called dead cotton is undesirable because of its poor spinning quality and its resistance to dyes."

Originally there were nine grades with "middling" considered the middle or average grade. But today the grading includes variations for color; as a result there are twenty-four possible grades. According to The American Cotton Handbook of 1965 (3), the United States Department of Agriculture recognizes three factors in classing cotton. These factors are grade, staple, and character, but each of these factors has a number of subdivisions.

Grade includes the color, quantity of foreign matter, and preparation. Color depends on three attributes: hue, lightness, and chroma. Hue means the actual appearance--whether the cotton is yellow, white, or gray. Lightness is the degree of neutral colors from white to gray to black. Chroma is the saturation, strength, or amount of color of the cotton. The color of upland cotton varies with conditions, and the amount of yellow color determines the grade. The color groups as recognized by the Department of Agriculture

are white, light spotted, spotted, tinged, and yellow stained. The plus group includes gray and light gray. Within each of these color groups are the grade divisions: good middling, strict middling, and middling.

Grades of cottons that have been affected adversely by a number of conditions are "spotted" and "tinged". The American Cotton Handbook of 1965 (3) defines spotted cotton as cotton which has been colored brown by contact with wet bolls, leaves, or stems. If this spotted cotton is mixed with white cotton, brown spots will show in the white. Tinged cotton is defined as that cotton in which the brown discoloration is more extensive than in the spotted samples. In the tinged group, the spots are of considerable size and are distributed evenly throughout the samples. Yellow stained cotton is cotton in which the fibers are almost entirely discolored, giving the samples a slightly mottled tan color. Gray cotton, sometimes called blue stained, is cotton that is discolored by exposure to adverse weather conditions. Long exposure produces a light slate color.

Upland cotton, especially if growth is prematurely stopped by frost, may have a yellow color that varies in depth, according to Publication 310 of the U. S. Department of Agriculture (4). Green leaves, branches, and bolls from the cotton plant usually are considered a prime source of discoloration. Oil and grease may cause stains; but usually

these are of minor concern. The bollworm and leaf-worm are responsible for some discoloration. During early morning and times of moisture, droppings from these organisms will stain the cotton.

Researchers at the Southern Regional Research Laboratories (5) reported the use of cottons that were badly damaged by Diplodia, Aspergillus Flavus, Nigrospora Oryzae, and Rhizopus Nigricans in blends of low percentage with a white control cotton in "Spotted Cottons: Their Effects on Product Properties and Spinning Performances." Limited quantities of cotton, identified as weathered and unweathered, were used with a control cotton without crossblending. In testing the blended cottons, which included as much as 10 per cent of the fungus-damaged fibers, little effect was noted on the strength and uniformity of yarns spun with a warp twist; but end-breakage in spinning was increased. When the filling twist process was used, there were losses in yarn strength at all levels; and end-breakage in spinning increased rapidly as the per cent of damaged cottons was increased. The weathered and unweathered cottons produced comparable quality yarns; but end-breakage in spinning for the unweathered was higher. The explanation included a possible "leveling-out" of the moisture equilibrium with the time of weathering. Another possible explanation involved the slightly higher Micronaire reading of the unweathered cottons.

Further, this research indicated that, when bleached fabrics were used, little difference in color between the blends and their controls could be observed. Bleached, mercerized, and dyed fabrics indicated no serious defects due to the use of as much as 50 per cent of the high spotted cottons.

The production of spotted cottons also has been affected by economic factors. Mechanization of cotton farming has increased the production of spotted cotton. Indications are that the discolored grades are more profitable for the farmer to produce. In addition, some manufacturers tend to buy the spotted grades because of the price differential.

A harvesting research study reported by Rogers and Bonner (6) showed that different methods of harvesting had no significant effect on the fiber and spinning performances. These same methods, however, had a definite effect on net cash return to the producer. A comparison of cotton harvested by hand with cotton harvested by machine showed little differences in strength and performance tests; but lower production costs out-distanced the lower selling price of light spot cotton. This study showed that once-over stripping after frost was the most profitable method of harvesting cotton. Also, the ill-effects observed when

spinning the cotton so produced were attributed to time of harvest and the Micronaire level at the time.

Other causes of discoloration given by the report cited above include the pH and high iron content caused by contamination of clay soil which resists bleaching by sodium hypochlorite solution; and HS or high sugar, characterized by a high level of reducing sugars and found in areas where plants are subjected to low temperatures at the time of boll opening.

Leaf is the amount of trash, such as leaves, stems, and foreign matter, in the cotton. This foreign matter becomes imbedded in the fibers and is a detriment to the manufacture of fabrics. Large amounts of leaves, which usually crumble easily, definitely lower the grade of the cotton. These fragments, if small, are practically impossible to remove and show up later as dark spots in the fabric. The cotton with the least foreign material is the best spinning material.

Preparation involves the processing of the cotton from the field to the ginned bale. It determines the smoothness or roughness of the fiber. The ginning is especially important, since improper ginning of the fiber can cause stringy or "ropy" tufts in the fiber. Wet or green cotton tends to have "naps" as distinguished from "neps" caused by the improper development of the cotton fiber.

The mechanization of the cotton industry has caused some of these conditions. Bulletin 452 of the Experiment Station at The Agricultural and Mechanical University, College Station (7) comments that picking cotton by machine is difficult for several reasons: the crop does not mature uniformly in the field, nor on one plant. Also plant and leaf stain the fiber if vegetation is squeezed during the picking process. The Cotton Handbook (3) states that cotton gathered by mechanical pickers is usually of a low grade, since no amount of cleaning can remove all of the trash collected. Irregularities in cotton fibers may result, also, from the use of additives required in mechanized cotton farming. These additives usually include defoliants and insecticides. The mechanical harvester operates more efficiently if the plant is defoliated. As a result, the grower applies certain defoliants at a time when some of the crop has reached maturity, or is near this stage of development. These defoliants in some instances may spot or tinge the fiber. Also insecticides may be needed during late bollworm infestations, and these also may discolor or stain the fiber. The National Cotton Council in an editorial in Textile World (8) states that 83 per cent of cotton fabrics are chemically treated; and, if the grower uses too many additives, these may affect the results in dyeing.

Weather conditions are dominant factors in the irregularities of the cotton fiber. Stout (9) comments that,

although most cotton fibers usually are creamy white in color, the color varies with the weather from the time the boll opens until the cotton is harvested. This author lists rain, dust, and dirt which may have touched the open boll as causes for stains on the fiber. A report by the Cotton Research Committee of Texas (10) has confirmed this view in stating that field exposure to rain and dust results in discoloration of cotton fibers, thereby reducing grade.

Staple refers to the length of the fiber. The actual length of the natural fiber in inches determines the classification as to staple. Cotton staples range from 13/32 of an inch to 1 1/4 inches for upland cotton. The American Egyptian cotton ranges from 1-15/16 inches to 1 1/2 inches in length.

Character involves all qualities of cotton not included in grade and staple length. Character usually provides information on the spinning utility of cotton. Cottons of the same grade and staple may have different spinning qualities. Good character cottons are hard bodied, fine fibered, and strong; whereas, poor character cottons are weak, soft, and irregular. Qualities of cotton are fineness, maturity, strength, uniformity of length, twist, and convolutions. Even though these many factors are present in determining the economic value of a bale of cotton, color

seems to be a dominant factor in determining the value and grade of cotton fiber.

A Plains Cotton Growers Bulletin entitled "Analysis of Price Quality and Supply of Light Spotted Cotton" (11) indicated that, according to United States Department of Agriculture research, there is little difference in the fiber performance of white and light spotted cotton. The light spotted had slightly higher waste, more yellowness, less Micronaire, but little difference in strength, length, and uniformity. Spinning test data showed some waste in the spotted cotton, but little difference in the cotton's appearance or strength. The color of yarns exhibited little difference in reflectance and yellowness, whether bleached or unbleached. The price differential, however, was rather extensive, with the price of the whites nearly 20 per cent more than the light spotted.

Other research work by Rogers and Bonner (6) has shown that there are few differences in the performance qualities of hand-picked and machine-harvested cotton. Eight samples of cotton, all produced under similar conditions, have been tested as fillers in weaving light-weight twill. The tests for strength and dyeing qualities indicated that there was very little difference in the spotted and the white cotton. Once again, however, the light spotted cotton produced more net cash return.

Irregularities are the dominant characteristic affecting the dyeing of cotton textiles. These irregularities have been attributed to practically every variable condition of growth, fiber morphology, and processing from harvesting through finishing according to authors of an intersectional technical paper reviewed at the 1962 AATCC Convention (12). Some of these variables are: (a) it generally is accepted that rain-grown cottons dye an appreciably deeper shade than irrigated cottons; (b) immature cottons respond differently with respect to dyeing; (c) cottons of different color fluoresce differently and dye differently; (d) weathered cottons respond differently with respect to dye acceptance than the early harvested cottons; (e) high mineral contents cause dyeing problems; (f) excessive drying during ginning, or any other process, may cause changes in dyeing characteristics; and (g) shade differences in natural cotton are retained through subsequent bleachings and dyeings. Even though researchers recognize the enormity of the variables which affects the dyeing results on cotton, their solution has been to blend the fibers as thoroughly as possible. This is not always possible, since mechanical processing has prevented the feasible blending of fibers.

In tests reported in the intersectional paper, twelve selected cottons and a control cotton were knitted into sample tubes. The cotton varied in staple length,

strength, and level of discoloration. Six mills made single dyeings of the fabric, then the dyeing characteristics of each sample were compared to each other and related to the control cotton. Tests of the effect of the initial color on subsequent dyeing were made. The evaluations showed that each cotton from the separate mills dyed a better match with each other than with the control cotton. Statistical analysis indicated that the most practical test for predicting whether one cotton would match another is based on the Micronaire readings. Whenever two tests are to be used, then a combination of maturity and alkali retention values should be selected. The immature cottons dyed to a lesser degree in the center, showing that less solution was absorbed because of greater swellability. The original off-color of the long staple cotton probably was the cause of the different dyeing characteristics.

This research indicated that the dyeing of cotton fibers is a complex process. Preparation of fabrics for dyeing, types of dyes, and methods of dyeing represent just a few of these complexities.

Ward (13) defined the bleaching of cotton as the whole purification process for making cotton fibers whiter. Although the removal of dirt and impurities constitute the primary purpose of bleaching, the final use of the fiber tends to determine the method of bleaching. In most instances,

especially when dyeing, bleaching is done not only to remove impurities but also to increase the absorption qualities of the fiber.

Peters in Textile Chemistry (14) makes the comment that the rather drab initial colors of natural fibers are improved when their impurities are cleaned and purified by scouring and bleaching. Scouring and bleaching is done either to give the fibers a pure white finish or to prepare them for dyeing and printing. Of the cotton spun for industrial purposes in the textiles industry, only about 20 per cent will not be bleached. A variety of methods are used to bleach cotton goods, but the hot alkali treatment seems to be used most often. The extent of scouring and bleaching depends on many factors: (a) the type, color, and cleanliness of the cotton; (b) the twist and count of the yarn; (c) the construction of the fabric; and (d) the discoloration of the cotton. The purpose of bleaching is primarily to remove the non-cellulosic impurities without modifying the cellulose. The impurities causing the most difficulty are wax, plant fragments, and stains. Cotton fiber usually contains foreign materials that ginning does not remove. These impurities can be removed to a satisfactory extent with an alkaline scouring process. Failure to remove this material is apt to form dark colored particles in the fabric. In addition, the dyeing properties of the impurities are different from those of cotton. The usual methods of

bleaching cotton fibers according to The Cotton Handbook (16) involve the use of hypochlorite, chlorite, or hydrogen peroxide. Each of these agents is oxidative in reaction to the colored impurities or pigments in cotton. Also, agents are selective in that they are attracted to the impurities in the cotton rather than to the cellulose. This selectivity, however, may depend on the conditions of treatment.

The optical bleaching agents are used to improve the appearance of bleached goods. These agents are actually fluorescent dyes and do not bleach. Some of the brighteners are resistant to oxidation and can be added to the bleach bath, while others must be applied in the last rinse after bleaching.

Killheffer (16) classified dyes in relation to the chemistry of the product and method of application. He stated that today the buyer of textiles is more interested in a specific level of color fastness than in the dyes and methods used. Therefore, his studies were concerned with the kinds of dyes available, the capabilities of the dyes, and their uses under specific conditions. The classes of dyes, according to this author, are acid, azoic, basic, disperse, fiber reactive, ingrain, mordant, sulphur, and vat.

According to AATC Monograph No. 2 (17), there are four fundamental steps in the application of a vat dye; these are: reduction, dyeing, oxidation, and after-treatment.

Since vat dyes are not soluble in water, they must be put into solution in order for the goods to absorb the dye. The solution normally used is composed of caustic soda and sodium hydrosulfite. Dyeing involves the immersion of the fabrics into the sodium-leuco solution. Oxidation causes the dye to revert to the insoluble state. This process can be accomplished by drying in air, although treatment with an acid expedites the process. After-treatment insures color-fastness and is accomplished by treating the fabrics in a hot detergent bath.

Leuco-esters are stable water-soluble products which are used with the non-water-soluble vat dyes. The color of the original vat dye from which the leuco-ester is derived is developed on the fiber by oxidizing agents in the presence of acids. The affinity of the leuco-esters for vegetable fiber is less than for animal fiber.

The principle characteristic of the soluble vat dyes is their ability to change readily to the original dyestuff. This process is short and is accomplished by acid oxidizing baths. The reaction involves the splitting of the mono-sodium salt of sulfuric acid in the presence of an oxidizing agent, with the direct restoration of the ketonic groups and the regeneration of the original dyestuff. The leuco-esters are sensitive to light and may be affected by light whether in the powder or paste form, in solution or in the dyeing

process before developing occurs. Soluble leuco-esters have the unique property of penetrating cotton and linen yarns, and consequently they are used in conjunction with caustic soda and sodium hydrosulfite to form the soluble sodium-leuco form of dye. An adequate amount of caustic soda is required for the reaction to take place. The sodium-leuco compound reverts to its former state and color by an oxidation process. Oxidation will take place gradually in the air. In dyeing, however, it is expedited by an acid bath.

Retarding agents are effective in obtaining level dyeing. The use of retardants sometimes causes a color loss and an increase in cost. However, retardants are essential in some dyeing situations. No single levelling agent works with all dyes, and the type needed is determined by the fiber. Retarding agent action is accomplished either by a loose combination with the fiber which hinders easy access by the dye, or by a loose combination with most of the dye molecules, which break up as fast as free dye is absorbed by the fiber. Difficult levelling problems may be solved by combining the agent during temperature manipulation. Retarding agents are necessary with high temperature dyeing, especially with light shades. The most widely used agents are animal glue and the lignin sulphonate products. The agents are normally used at the rate of 1/16 to 1/2 ounce per gallon of dye liquor.

A number of studies concerning the dyeing of cotton fibers have been conducted in the Textile Laboratories of the Texas Woman's University. Beauchene (18) studied the effect of natural minerals on the color of dyed cotton fabrics using twenty-five fabrics, half of which were bleached and the other half were untreated. These sets of bleached and unbleached fabrics were dyed with selected dyes; then spectrophotometric measurements were made to determine dominant wavelength, purity, and visual efficiency of each specimen. The author concluded that minerals were significantly correlated with purity rather than with dominant wavelength or visual efficiency. Since purity is an indication of the saturation of the dye color, perhaps the naturally occurring minerals of the fibers tended to affect the amount of dye absorbed.

The relationship between the molecular weight of a dye and its dyeing behavior on cotton of various Micronaire levels was made by Brakebill (19). A total of 20 dyes of different molecular weight and configuration was used, including the following: 13 direct dyes, five vat dyes; one special process vat dye; and one azoic dye. Samples were laundered and bleached under specific conditions before dyeing, and then were evaluated by spectrophotometric readings and visual examination by a panel. This research worker concluded that, to a limited extent, the molecular weight of a direct dye could be associated with optical density differences.

The vat dyes used in the study were too few in number to permit extensive comparison, although vat dyed cottons showed a wider scatterment of optical density than did the direct dyed fabrics. Cotton of Micronaire 2.9 differed in optical density from all other cottons. Laundering reduced the optical density of the various dyes, although vat dyed fabrics lost less color than did direct dyed fabrics.

Brakebill (20) also studied the relationship between the properties of cotton fiber and the characteristics of cotton yarns with respect to dyeing. Cottons from Texas, New Mexico, and California were utilized in this research. The dyes used included a high molecular weight blue vat dye and a low molecular weight azoic dye. The skeins of fiber were tied loosely with the same number of skeins dyed each color. Afterwards the reflectance was read on the spectrophotometer. This author concluded that the desorption of dye by the low Micronaire cotton was greater than that of the cotton of high Micronaire, and that the red dye of low molecular weight had a greater tendency to rinse out than did the blue dye of high molecular weight. Also the blue dye had a greater tendency to produce level dyeing than did the red dye.

The effects of mineral impregnation of cotton on its dyeing properties was investigated by Trost (21). This investigator treated specimens with 1.0 per cent, 0.5 per

cent, and 2.0 per cent concentrations of inorganic nitrates, as follows: aluminum, calcium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, and zinc. The yarns were impregnated with the various nitrates and then were dyed different colors. The color differences were obtained by measuring the reflectance by means of the spectrophotometer. It was found that grey and orange dyed fabrics were affected by all minerals, that zinc affected all colors except blue and red, that manganese and iron affected the color of all six dyes, that copper stained the fabrics less than manganese and iron, and that aluminum, cobalt, and nickel had little effect on color. The colors least affected by minerals were in this order: scarlet, blues, green, turquoise, gray, and orange.

Glasscock (22) investigated the relationship between the kinetics and fiber properties of cotton. Six different types of cotton fiber from five different growing areas were tested. Waxes and gums were extracted and a constant humidity was maintained during the experiment. Two dyes, Dye Prototype 629 and Direct Red DCB Extra Concentrated, were tested. The Beckman DU Spectrophotometer was used to measure dye concentration. Kinetics measurements were derived from an apparatus consisting of three-necked pyrex flasks each fitted with a stirrer in one neck, a condenser in the second, and a thermometer in the other, all immersed in a constant temperature oil bath. The cotton was ground in a Wiley Mill to prevent clogging.

Conclusions reached from this investigation were these: that fiber fineness is the most important factor in dyeing; that supposed differences in dyeing properties of irrigated and rain-grown cottons were not substantiated in the study; that equilibrium absorption of dye by different cottons was related to Micronaire; that a low temperature was conducive to minimizing the differences in rate, as well as equilibrium of absorption of dyes.

Klein (23) observed the effects of three types of radiation--nuclear energy, gamma radiation, and sunlight, on dyed cottons. Ten vat dyes, eight reactive dyes, and one azoic dye were used to dye the fabrics. Exposures to nuclear and gamma radiation were made at the Texas Agricultural and Mechanical University and to sunlight by use of the Fade-ometer in this laboratory. Exposure effects were measured with the spectrophotometer. The results showed that vat dyes were the most color retentive of all the dyes, that the color loss after six exposures to different levels of nuclear radiation was small, and that gamma radiation had less effect on vat dyes than nuclear or sunlight radiation. The reactive dyes were affected greatly by nuclear energy, losing much of their original color. The molecular weight of the dye used was related to the fading of the dyed fabrics less than to the type of dye or to the source of radiation.

Lathrop (24) studied the development of dye specifications for seasonal colors. Samples of fabric weighing

seven grams each and dyes selected from the IN, IW, IK groups were used. The tests involved laundering, pressing, light, perspiration, dry cleaning, crocking, and gas fading. Evaluations were made by viewing panels and by spectrophotometric readings. This study revealed the fact that vat dyes were well suited to large scale production, that vat dyes penetrate the fiber better than other types in highly twisted yarns and fabrics, and that vat dyes may be used safely for alkali sensitive yarns because contact with alkali liquid is of short duration.

Pal and Esteve (25) investigated the relation between color fiber properties and dye absorption at equilibrium. Nine samples of mercerized and unmercerized cotton and two direct dyes, high molecular weight Chlorantine Fast Green BLL and low molecular weight Diphenyl Fast Red 5BL, were used. The samples were mercerized with sodium hydroxide, dewaxed with carbon tetrachloride, and dyed in a 0.2 per cent dye solution. The dye solution was refluxed for one hour, then the absorption of barium hydroxide was determined. The cotton sample was placed in the solution and agitated for an hour. Spectrophotometer readings were used to measure the results. These authors reported the following: that a definite relationship existed between absorption and Micronaire; that a linear relationship was observed between absorption and maturity of the cotton; and that one sample of pima cotton did not follow these relationships. Since pima cotton is a

long staple cotton these tests indicated that factors other than maturity are involved in dye absorption. The results showed, however, that upland cotton did have a relationship between absorption and maturity. The effect of Micronaire on color of the dyed fabric was not noticeable either in the mercerized or the unmercerized samples.

Siao (26) studied the results of application of vat dye formulations to cotton of different Micronaire values. Samples were prepared by applying varying amounts of dye and heat to the fabrics. Color fastness was tested by laundering, exposing to light, and by perspiration tests--acid and alkaline. The effects of the treatments were evaluated by spectrophotometric measurements and by visual readings. The results showed that mint green had the greatest total deviation in reflectance and dilly blue had the least. These were correlated with the visual difference values determined by a panel of color specialists. The bluish green and blue group of dyes had the best overall colorfastness, while the yellow green and green group had the poorest colorfastness.

PLAN OF PROCEDURE

EXPERIMENTAL FABRICS

Twelve lots of upland cotton classified according to grade and color were chosen for this study. The raw cotton was purchased from the Plains Cotton Growers, Incorporated of Lubbock, Texas. This cotton was spun into number 12/1 yarns by the Textile Department of Texas Technological University in Lubbock, Texas, and the fabric was constructed by means of the circular knitting process by Enterprise Incorporated of Dallas, Texas. The 22 gauge knit fabric so obtained provided the experimental samples tested in this study.

The 12 lots of cotton included three grades: middling, strict low middling, and low middling. The colors included white, light spotted, spotted, and tinged for each of these three grades. Summary A and Figure 1 show the fabrics as classified by lot number.

SUMMARY A

Classification of Experimental Fabrics

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

DESCRIPTION OF DYES

Vat and direct dyes were selected for application to the various cottons. They included a variety of hues which might be suitable for various types of wearing apparel, on the assumption that the spotted cotton under investigation might be used in manufacturing different types of outerwear. An attempt was made to select some colors which were suitable for the immature cotton as well as for the better grades.

Palanthrene Vat Dyes were selected from the color card catalogue of the Badische Analin-and-Soda-Fabrik Company who provided samples of the dyes for the study. The direct dyes were chosen from the color card index by Sandoz who furnished these samples. As nearly as possible the direct dyes were selected to match the colors of the vat dyes.

Information concerning the colors and color index names of the experimental dyes selected from the two general categories, mentioned above, is given in Summary B.

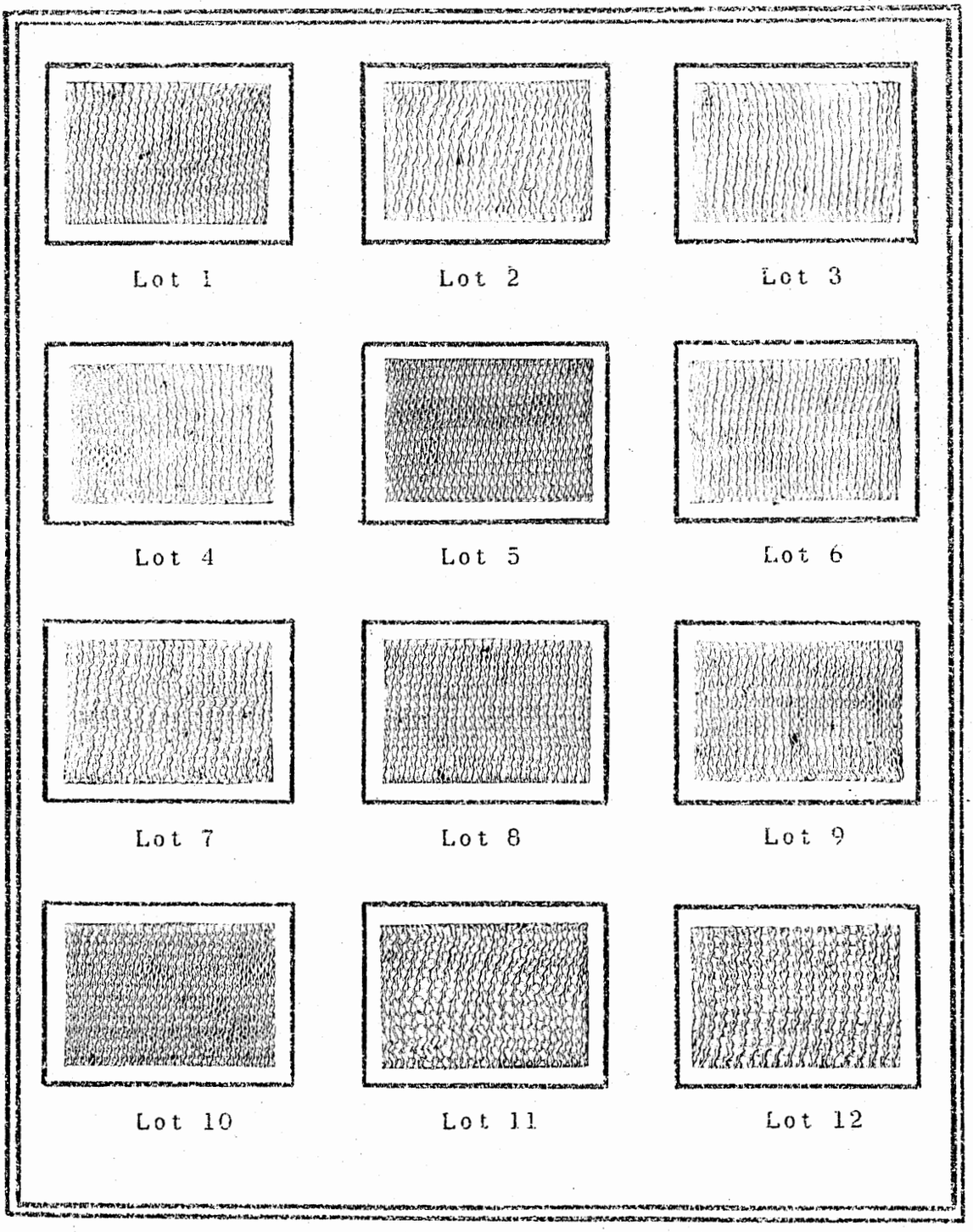

FIGURE 1

CLASSIFICATIONS OF EXPERIMENTAL FABRICS

SUMMARY B

Experimental Dyes

VAT DYES		DIRECT DYES	
Hue	Color Index Name	Hue	Color Index Name
Red	10	Cuprofix Red	184
Orange	2	Pyrozal Fast Orange	61
Brilliant Yellow	--	Lumicrease Yellow	98
Violet	13	Lumicrease Red Violet	47
Brilliant Green	1	Lumicrease Green	68
Blue	6	Chloramine Blue	14
Navy	18	Cuprofix Navy	252
Olive	13	Lumicrease Olive	70
Brown	1	Cuprofix Brown	3
Black	9	Cuprofix Black	91

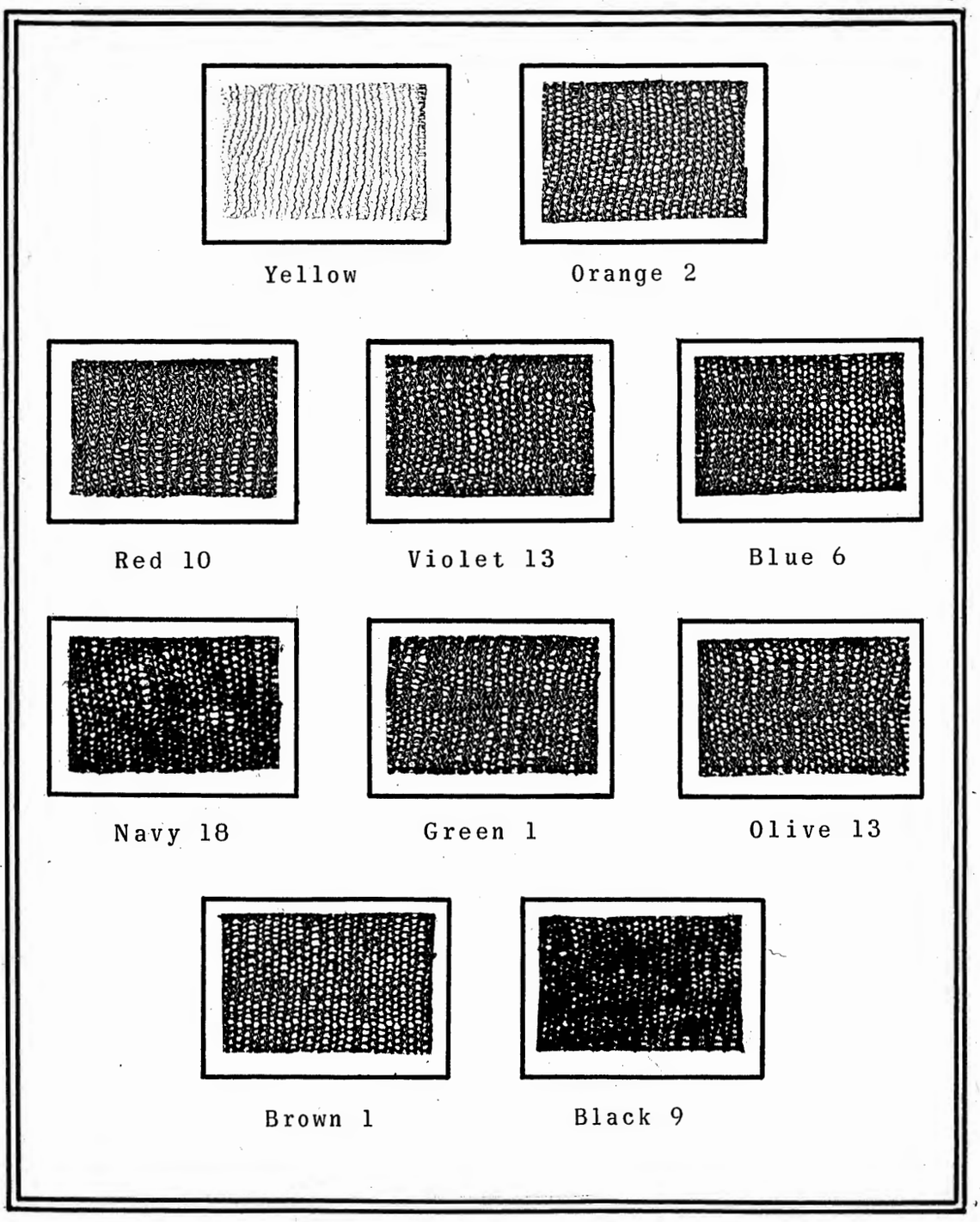

FIGURE 2

EXPERIMENTAL VAT DYESTUFFS APPLIED TO UNBLEACHED FABRIC FROM LOT 1

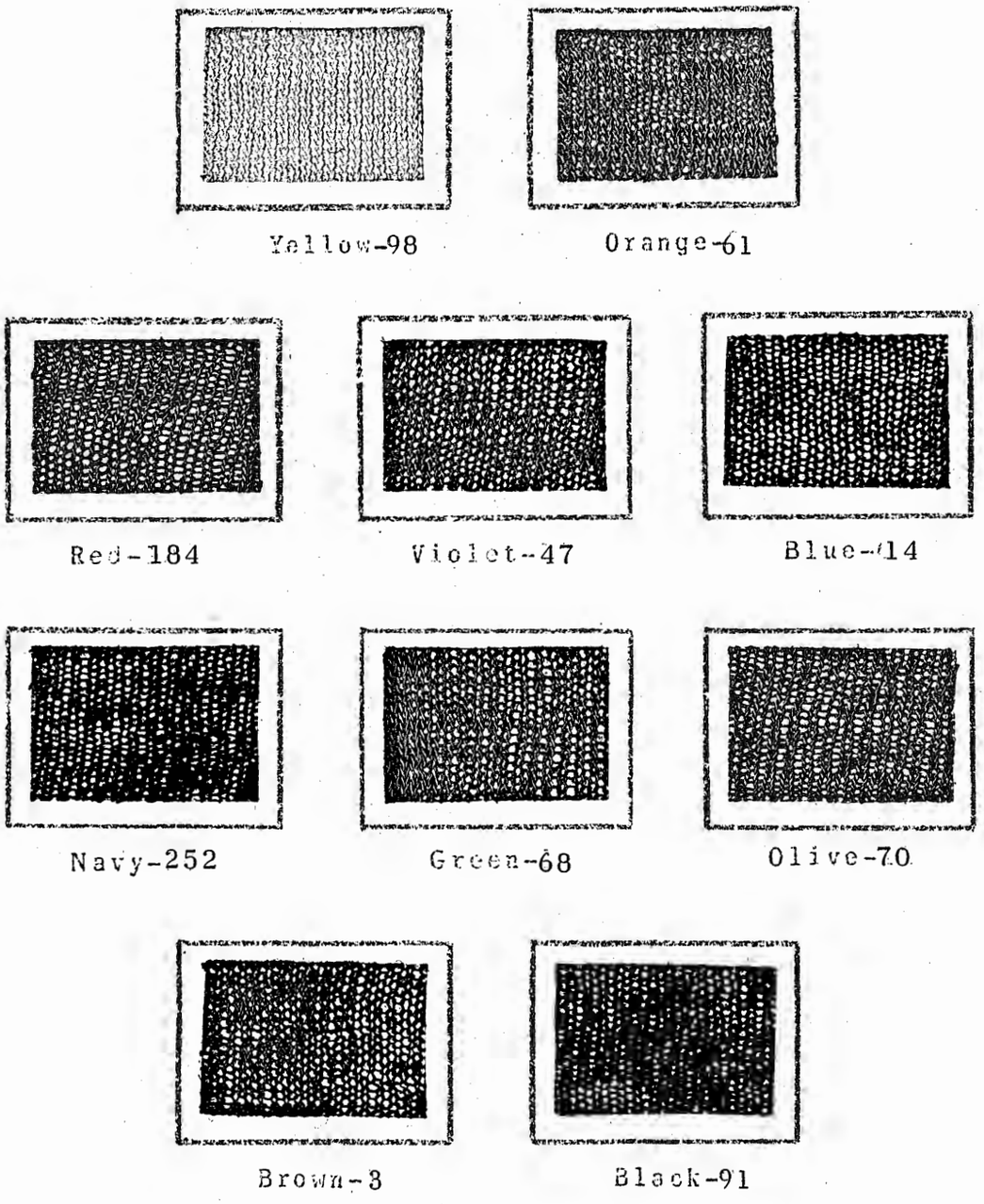

FIGURE 3

EXPERIMENTAL DIRECT DYESTUFFS APPLIED TO UNBLEACHED FABRIC FROM LOT 1

PREPARATION OF EXPERIMENTAL FABRICS FOR DYEING

DIVISION OF FABRICS

Nine and one-half yards of fabric from each of the twelve lots of cotton were required for the tests. Approximately eight inches were needed for a sample test, which made an 8-gram sample. This sample size allowed an adequate amount of fabric for three samples, each one cut two and one-half inches by five inches. Two samples weighing eight grams each were taken from each lot of fabric for each vat dye, and two similar portions were used for each direct dye. Each of the 12 lots of experimental fabrics was cut into a total of 48 specimens, and each was weighed carefully on the Mettler Balance to insure that all weights were within one milligram of the specified eight grams. Proper identification was assured by assigning a specific label to each lot of fabric. This label was sewn to the sample of fabric. One-half of the samples of experimental fabrics was dyed in the greige state, while the other half was scoured and bleached according to a method suggested by a producer of peroxide bleach.

SCOURING

The scouring procedure was based on a liquor ratio of 18:1, or 18 milliliters of liquid to one gram of fabric.

The liquor consisted of 0.06 gram of sodium carbonate and a comparable amount of neutral soap dissolved in 18 milliliters of distilled water for each gram of fabric. The sample and liquor were put into a steel cylinder, inserted in the Launder-Ometer, and scoured for 30 minutes at a temperature of 190° F.

After 30 minutes of scouring, the sample was removed and subjected to five rinses in 500 milliliters of distilled water for each rinse.

BLEACHING

For bleaching, the sample was returned to the steel cylinder and saturated with a bleaching liquor composed of 18 milliliters of water, 0.18 gram of sodium silicate, and 0.18 gram of peroxide bleach for each gram of fabric. The sample then was placed in the Launder-Ometer for 45 minutes at a temperature of 190° F. At the end of the 45 minute period, the sample was removed, rinsed five times in distilled water, and spread on the straight of the grain to dry.

PROCEDURE FOR VAT DYEING

Directions for the vat dye process were taken from Palanthrene Dyestuffs on Cotton, published by the Badische Anilin-and Soda-Fabrik AG Company of Charlotte, North

Carolina (27). Some modifications in the process were made according to suggestions provided by one of the Company's chemists.

Bleached and unbleached samples of fabric with the same lot number were dyed at the same time. Each sample was dyed separately in a 1000-milliliter beaker, a steam dye pot being used for the dyeing process.

Each sample was wet out in 160 milliliters of a 0.05 per cent rapid wetting agent at 120° F. for 10 minutes. Then the sample was rinsed in a bath of 500 milliliters of distilled water for each of five separate rinsings.

A 2.0 per cent dye bath was used for all colors except brown, navy, and black. For brown, a 2.5 per cent solution was used, with a 10 per cent solution for navy, and a 14 per cent solution for black was employed. These percentages were based on the weight of the fabric with a 20:1 ratio of liquor to fabric. An attempt was made to obtain the medium value of each color according to the color card catalogue.

The red dye was applied by a different procedure. Salt and a lower temperature were used in order to get the desired results. Black also required a different dyeing process. The manufacturer's color chart suggested a 14.0

per cent dye solution as a starting bath, with the addition of a 9.0 per cent solution, after one-half of the dyeing cycle had been completed.

Summary C shows the per cent of vat dye, the amount of chemicals and the temperature used for each color during the dyeing process.

SUMMARY C

Vat Dye Formulas

HUE	PER CENT OF DYE	DYEING PROCESS				
		NaOH (gms)	$Na_2S_2O_4$ (gms)	Basogol (gms)	Salt (gms)	Temperature (Fahrenheit)
Red	2.0	0.48	0.48	0.01	0.5	75°
Orange	2.0	0.48	0.48	0.01	0.0	128°
Yellow	2.0	0.48	0.48	0.01.	0.0	128°
Violet	2.0	0.48	0.48	0.01	0.0	128°
Green	2.0	0.48	0.48	0.01	0.0	128°
Blue	2.0	0.48	0.32	0.01	0.0	128°
Navy	10.0	0.96	0.96	0.01	0.0	128°
Olive	2.0	0.48	0.48	0.01	0.0	128°
Brown	2.5	0.48	0.48	0.01	0.0	180°
Black	14.0	1.92	1.92	0.01	0.0	128°

In order to obtain a uniform color for all samples, an exact procedure for dyeing was planned. The exact amounts of sodium hydrosulfite and other chemicals to be added were of major importance. Also the time of injection of the dye and the time sequence of each step were vital factors in securing the desired color level. In order to save time and to maintain accuracy, separate stock solutions of the rapid-wetting agent, the dye, and the soap for boiling off were made prior to the dyeing of each color.

A bleached and an unbleached sample, each in a separate container, were treated with the rapid wetting agent for 10 minutes at 120°-140° F. This fabric was rinsed thoroughly in warm water. The dye solution and Primasol were placed in the dye pot and heated to a temperature of 120°-140° F. This fabric was rinsed thoroughly in warm water. The dye solution and Primasol were placed in the dye pot and heated to a temperature of 120°-140° F. When the solution reached the correct temperature, the fabric was immersed therein and stirred for 10 minutes. The caustic soda, which previously had been dissolved with a small amount of the dye solution, was added and stirred for 10 minutes. Basogol P and one-third of the sodium hydrosulfite next were added, followed by a 10-minute period of stirring. Then another third of the sodium hydrosulfite was added and another 10-minute period of stirring ensued.

The remaining third of the sodium hydrosulfite was added, followed by a final 10-minute period of stirring. The fabric was removed from the dye bath, rinsed thoroughly to remove the caustic soda, and then oxidized in a bath of 160 milliliters of 0.2 per cent sodium perborate solution at 120° F. for 10 minutes. Following this oxidizing bath, the fabric was removed, rinsed thoroughly, and then boiled for 10 minutes in 160 milliliters of 0.2 per cent soap solution. Finally the fabric was rinsed thoroughly and spread out to dry.

PROCEDURE FOR DIRECT DYEING

The dyeing procedure for direct dyes differed from the procedure for vat dyes, both as to method of adding the chemicals and as to chemicals used. The fabric was wet in the same rapid wetting agent used for vat dyeing, then rinsed five times in 500 milliliters of water for each rinse. The soda ash and salt were mixed with the dye before the dyeing process was begun. The soda ash acted as a retarding agent, thus promoting level dyeing. Summary D shows the chemicals used in the dyeing process, and the conditions of their application, as recommended by Sandoz Chemical Works, Incorporated (28).

SUMMARY D

Direct Dye Formulas

(Per One Gram Specimen)

HUE	PER CENT OF DYE	DYEING PROCESS			
		Soda Ash (gms)	Salt (gms)	After Treatment	Temperature (Fahrenheit)
Red	2.0	0.1	4.25	Cuprofix	170°
Orange	0.5	0.1	4.25	Potassium Bichromate & Copper Sulfate	170°
Yellow	0.5	0.1	4.25	Potassium Bichromate & Copper Sulfate	170°
Violet	1.0	0.1	4.25	Potassium Bichromate & Copper Sulfate	170°
Green	2.0	0.1	4.25	Sandofix	170°
Blue	0.5	0.1	4.25	Potassium Bichromate & Copper Sulfate	170°
Navy	4.0	0.2	9.5	Cuprofix	170°
Olive	2.0	0.1	4.25	Sandofix WE	170°
Brown	2.0	0.1	4.25	Cuprofix	170°
Black	6.0	0.2	9.5	Cuprofix	170°

The directions given in the shade book by Sandoz Chemical Company were followed, since this company furnished the direct dyes. These directions suggested the use of soda ash and salt at a level of one per cent and 10 per cent, respectively, based on the weight of the goods to obtain a medium shade of dye. An attempt was made to secure the medium color shade in vat dyes, with the same shade attempted in the direct dyes. The ratio of liquor to fabric for the direct dye was 20:1. To each 1000 milliliter beaker was added 160 milliliters of dye liquor. The eight-gram sample was treated in this solution for one hour at 170° F. No addition of chemicals was necessary after the sample was placed in the solution, and thus one person was able to dye six samples at a time. The beakers were placed in the dye pot with constant stirring for one hour. Then the samples were removed from the dye liquor and rinsed five times as in previous treatments.

To give improved fastness to light and washing, an after-treatment was applied to each of the dyed samples. Several suggestions were given in the shade book provided by the company. A combination of two per cent potassium Bichromate and two per cent copper sulfate was chosen to treat all of the dyed samples except those with green and Cuprofix colors. This treatment imparted improved fastness to laundering and to light. Shades of green and olive were altered by the above treatment, and hence, a 2.0 per cent

Sandofix WE was chosen for these colors. The Cuprofix dyes required a special preparation called Cuprofix after-treatment, involving a two per cent solution. The after-treatment was applied to the dyed fabric for 20 minutes at 160° F., with the sample rinsed five times, and then spread out to dry.

PREPARATION OF SAMPLES

After the 12 lots of cotton had been dyed, they were marked with the appropriate lot number for identification. Three samples, each 2.5 by 5.0 inches, were cut from each lot of fabric, one for an initial sample, one for exposure to light, and the other for laundering. Some of the fabric was used later for mounting in the dissertation. Iron-on tape was used to mark each sample with its respective lot number and to indicate whether the sample was bleached or unbleached. After marking, each sample was subjected to the tests described below.

LAUNDERING

The samples were laundered in an Atlas Launder-Ometer, using an accelerated laundering test designed for the evaluation of the wash fastness of textiles which are manufactured to withstand frequent launderings.

This 45-minute Standard Method Test, according to AATCC (29), should simulate the color loss and abrasive action of five average hand, commercial, or home launderings. Test IIIA from the Standard Method was used with some variations.

Through the use of appropriate conditions of temperature, alkalinity, and abrasive action, the loss of color was obtained in a conveniently short time. The abrasive action was accomplished by the unrestricted actions of the steel balls and the use of a low liquor ratio. Distilled water was used for the laundering tests. After each laundering period, fading was measured by means of the Beckman spectrophotometer.

After the laundering period, the sample was removed from the can and rinsed for two one-minute periods in 100 milliliters of fresh distilled water at a temperature of 105^{o} F. for each rinse. During this period, the sample occasionally was stirred or hand squeezed. Following the rinsing, the sample was soured in 100 milliliters of a 0.014 per cent solution of acetic acid at 80^{o} F. for one minute. Then the sample was rinsed for one minute in 100 milliliters of distilled water at 80^{o} F. Afterwards the samples were spread out and pressed between absorbent paper towels with a hand iron.

Labeling for the laundry test was accomplished by the use of iron-on tape attached to each end of the sample. The lot number and the method of treatment of the fabric was written with a laundry pencil on the tape. Due to the abrasion of the steel balls during the test, this iron-on tape was not completely satisfactory and as a result the tape was reenforced with staples.

LIGHT EXPOSURE

The dyed samples were subjected to the Colorfastness to Light Test of the AATCC (30). The Atlas Fade-Ometer with the carbon-arc lamp, continuous light, was used for the test. Two samples were placed on each holder and faded for a period of five, 20, 40, 60, and 80 hours. After each exposure period, spectrophotometric readings were taken at 10 wavelengths between 400 and 850 millimicrons.

EVALUATION

The acceptance of the dye and the loss of color by each sample of fabric was determined by the use of the Beckman Spectrophotometer.

After the exposure periods of 5, 15, 20, 40, 60, and 80 hours in the Fade-Ometer, readings on the wavelengths of 400, 450, 500, 550, 600, 650, 700, 750, 800, and 850 millimicrons were taken on each sample of fabric.

The retention of the dye by each sample after laundering was determined by spectrophotometric evaluations after each five laundering periods at the wavelengths mentioned above.

In each of the evaluations for acceptance and retention of dye, the 10 readings were averaged and reported as the mean reflectance for each sample.

PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

The data concerning the results of the dyeing of knitted fabric from three grades and four color classes of Texas cotton were pooled for each type of cotton, with pairs of the types compared by means of the "t" test. These fabrics, which included twelve lots of cotton, were divided into two groups. One group was dyed with 10 different hues of vat dyes, while the other group was dyed with 10 corresponding hues of direct dyes. In both groups, one-half of each fabric was bleached before dyeing and the remainder was dyed in the greige state.

These fabrics were subjected to two tests: 80 hours of light fading by means of the Fade-Ometer, and 25 launderings by means of the Launder-Ometer. The Beckman D U Spectrophotometer was used to measure the light reflectance, which determined the color loss of the dyed fabrics after each fading.

The data obtained by the spectrophotometric readings were analyzed by means of the "t" test for the purpose of determining the amount of light reflectance, as noted above.

These readings were taken initially on the samples; and then they were made after five, 15, 20, 40, 60 and 80 hours of light fading in the Atlas Fade-Ometer. For laundering, the readings were taken initially, and again after five, 10, 15, 20 and 25 laundering periods, respectively.

The mean reflectance ratings for the 12 lots of cotton varied from 59.1 for the Low Middling Tinge variety to 72.1 for the Strict Low Middling White in the initial fabrics as can be noted from Table I (Appendix). A statistical comparison of the data for the three grades of cotton--Middling, Strict Low Middling, and Low Middling, showed that there was no significant difference between any of the cotton grades.

When a comparison was made between the four color grades, White, Light Spot, Spot, and Tinge, the reflectance of White was superior to that of Tinge ($P<0.05$). This constituted the sole significant comparison of six tests which were made on the color groupings of the greige goods.

SUMMARY OF THE VAT-DYED FABRICS TREATED AS ONE COLOR GROUP

INITIAL COMPARISONS

Comparisons were made of the findings resulting from reflectance readings for the 10 vat-dyed fabrics initially,

before subjecting them to light fading or laundering, with all data for the respective fabrics pooled. Results neither for the cotton initial colors nor for the grades of cotton were found to differ significantly. This was found for the comparison of bleached as well as unbleached samples.

EFFECT OF LIGHT EXPOSURE ON VAT-DYED FABRICS TREATED AS ONE COLOR GROUP

GRADE

After exposure to 80 hours of simulated sunlight, comparisons were made between all three grades of vat-dyed cotton fabrics for bleached and unbleached samples, respectively. No significant differences were found between the grades in either group with regard to color loss which was imposed by dyeing.

In comparing the bleached fabrics with those which were unbleached, there was no evidence of a significant difference for this variable. Hence, bleaching had no appreciable effect on the reflectance of fabrics with reference to grade when bleaching preceded light exposure of the dyed fabrics.

When analyzing the results of light fading within grades for this study, it was found that all grades showed significant differences in plotting the bleached against the

unbleached vat-dyed samples. No difference was found between the dyed and the dyed and faded, regardless of whether the fabric was bleached or unbleached before dyeing. The results obtained were consistent with reference to the three grades.

COLOR

Within the color groups of cotton, the same trend was found as within the grades. No appreciable differences were found when comparing vat-dyed fabrics before fading with the same vat-dyed fabrics after fading. This was true for the bleached as well as unbleached fabrics.

EFFECT OF LAUNDERING ON VAT-DYED FABRICS TREATED AS ONE COLOR GROUP

GRADE

After 25 laundering periods, the specimens showed no significant differences in light reflectance readings for bleached or unbleached dyed cotton, when comparing them to similar unlaundered dyed samples. This was true for all three grades of cotton.

There was no difference between bleached dyed and unbleached and dyed samples after 25 periods of laundering with reference to grade. When the initial unbleached and

vat-dyed specimens were compared with similar samples which had been laundered 25 times, the difference was significant ($P<0.05$) for all grades indicating that some fading resulted from laundering, even though the degree of fading was not a result of the initial color or grade of the cotton, but of the dye.

On making the same comparisons of initial bleached and dyed samples with similar samples after laundering, there were significant differences.

COLOR

The reflectance ratings of the unbleached, vat-dyed as well as the bleached, vat-dyed cottons in all cotton color groups varied little after the laundering test. In comparing the laundered specimens which were dyed in the greige state to the bleached and dyed specimens, no significant differences were found between the groups. The same pattern of variations was found in the treatment within color classes for laundering as was found in the treatment for grades after laundering. No difference occurred in the bleached dyed fabrics after laundering when they were compared to the bleached, dyed fabrics before laundering in three color grades: White, Light Spot, and Spot.

An indication of a slightly significant difference for the Tinged class, in comparing bleached, dyed fabric

before laundering to bleached, dyed fabric after laundering was seen ($P<0.10$). Also, the reflectance was greater in the laundered samples than in those not laundered, with a significant difference ($P<0.05$). Hence the vat-dyed fabrics subjected to laundering resulted in some fading, for which the dye and not the initial color of the cotton was responsible.

VAT DYES

An evaluation of the acceptance and retention of each of the respective vat dyes by the 12 experimental fabrics is reported in the following discussion. Statistical comparisons of spectrophotometric reflectance measurements of the dyed specimens in the initial and faded states made with reference to grade and color of cotton served as the basis for this evaluation.

The acceptance of each dye was determined by comparisons made on the initial fabrics which were dyed but were not subjected to the fading tests. One-half of each of the initial fabrics was bleached before dyeing and the remainder was dyed in the greige state.

Other comparisons were made after the specimens were exposed to 80 hours of light in the Fade-Ometer. These samples were subjected to fading at intervals of five, 15, 40,

60, and 80 hours, respectively. After each period of fading, the light reflectance readings were made with the Beckman DU Spectrophotometer. An average of the recorded readings was computed to provide data for statistical comparisons in the retention of dye by the experimental fabrics after light exposure.

A third group of data was acquired from subjecting vat dyed specimens to 25 laundering periods in the Atlas Launder-Ometer as described in the Methods of Procedure. After each operation of the Launder-Ometer, which represented five laundering periods, spectrophotometric readings were made which served as data in determining the effect of laundering upon the retention of the 10 respective vat dyes by the experimental fabrics.

VAT BRILLIANT YELLOW

Acceptance and Retention of Vat Brilliant Yellow on the Basis of Grade of Cotton

Acceptance of Dye. The greatest color change which was observed in the per cent acceptance of Vat Brilliant Yellow dye by the initial fabrics was in the Middling grade of cotton. For the bleached fabrics, Middling cotton sustained a 6.8 per cent change, while the Tinge grade of cotton showed the least acceptance, with an average of 3.3 per cent. In the unbleached cottons, Middling cotton also

manifested the greatest level of acceptance with a 10.5 per cent change, whereas unbleached again showed the lowest acceptance with a change of 7.8 per cent.

Some statistical differences were found in Vat Brilliant Yellow fabrics which were dyed but untreated. As can be noted in Summary E, the reflectance of the unbleached Middling cotton was lower than the reflectance of the bleached Middling cotton ($P<0.02$). Strict Low Middling cotton reacted to dyeing in a similar manner to that observed by the Middling grade. The unbleached fabrics failed to exhibit a reflectance comparable to that of the bleached ($P<0.05$). No other differences were found between the three respective grades of cotton either in the bleached or unbleached state.

Fading during Light Exposure. Statistical comparisons of Vat Brilliant Yellow fabrics bleached before dyeing showed that 80 hours of light exposure had caused a significant difference in the reflectance of the Middling grade of cotton ($P<0.02$). A slight darkening was evident after light exposure which may have been due to a chemical change in the dye caused by the ultraviolet rays from the carbon-arc lamp.

A lower reading was evident also in the Low Middling grade after light fading which caused a significant difference

from the initial yellow ($P<0.10$). No significant differences were found between the unbleached grades of these cotton fabrics.

A comparison of reflectance values within grades of cotton revealed no significant differences between the initially dyed samples and the dyed and faded samples, although the reflectance values were lower in each instance after light exposure. No significant differences were found between grades of bleached cotton after light exposure and only Low Middling showed a difference in the grades for unbleached cotton. Unbleached Low Middling displayed a higher reflectance than did unbleached Strict Low Middling ($P<0.05$).

Fading during Laundering. Laundering revealed a significant difference between the bleached and unbleached Middling cotton with the higher mean reflectance found in the bleached cotton ($P<0.05$). All three grades of bleached as well as unbleached samples exhibited significant trends with reference to fading after laundering when compared to their initial yellow dyed samples. Within the bleached fabrics, the differences from laundering were not as great as in the unbleached fabrics.

There were no differences between the reflectance values of the unbleached dyed and laundered fabrics with reference to grade nor were there differences within grades of bleached and laundered fabrics.

Acceptance and Retention of Vat Brilliant Yellow on the Basis of Color of Cotton

Acceptance of Dye. In the bleached fabric, the greatest acceptance of Vat Brilliant Yellow according to percentage calculations was in White cotton (10.0 per cent) and the least acceptance in the Tinge color group (-3.0 per cent). Here it was observed that the Tinged cotton, according to spectrophotometric readings, gave results which denoted an increased yellow color before dyeing than after dyeing, although this was not discerned visually. In the fabrics dyed in the greige state, White cotton revealed a higher percentage of acceptance of the Brilliant Yellow dye (13.1 per cent) than did the other groups, while Tinge cotton showed the least acceptance (7.2 per cent).

The natural color of the cotton had significant effects in some instances upon the acceptance of the Vat Brilliant Yellow dye when statistical comparisons of the data were made. In the unbleached fabrics, no differences were noted except between Light Spot and Tinge where a slight difference was favorable to Light Spot ($P<0.10$). A slight difference in reflectance was also noted between the bleached Light Spot cotton and the Spot cotton in which Spot was slightly superior ($P<0.10$).

Comparisons of the bleached and unbleached fabrics within each color classification revealed that bleached

Tinge had a significantly higher reflectance value after application of the Vat Brilliant Yellow dye than did unbleached Tinge ($P<0.02$). A slight indication of a difference was noted to favor bleached spot when compared to unbleached Spot ($P<0.10$).

Fading during Light Exposure. After 80 hours of light exposure, the per cent reflectance of Spot cotton in the bleached and unbleached fabrics was lower than the value of the initial color ($P<0.05$). White cotton had the same trend ($P<0.10$). A slight darkening effect of fading was responsible for this occurrence.

White cotton which was bleached before dyeing with Vat Brilliant Yellow had lower reflectance than Light Spot after 80 hours of exposure in the Fade-Ometer ($P<0.05$). In the unbleached dyed fabrics, Light Spot was superior both to Spot and Tinge with reference to reflectance ($P<0.01$).

There were no significant differences in reflectance between the color groups of cotton when compared to their initial groups in either bleached or unbleached goods, hence no trend for fading of Vat Brilliant Yellow was evident.

Fading during Laundering. The laundered fabrics of Vat Brilliant Yellow displayed a significant difference in all color classes when compared to their initial counterparts.

The bleached as well as the unbleached samples exhibited higher mean reflectance values after laundering than before. See Summary E.

In these laundered samples, bleached Spot cotton and bleached Tinge cotton groups showed significantly higher mean reflectances when paired against the unbleached groups ($P<0.01$ and $P<0.05$, respectively).

Unbleached White surpassed bleached Spot cotton in reflectance ($P\leq0.05$); and bleached Tinge surpassed bleached Light Spot cotton in this respect ($P<0.05$).

SUMMARY E

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LAUNDERED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT BRILLIANT YELLOW)

Comparison	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Light Spot	72.5 71.0	N.S.	72.6 69.8	$P<0.10$
White Spot	72.5 72.9	N.S.	72.6 68.4	$P<0.05$
White Tinge	72.5 74.9	N.S.	72.6 69.5	N.S.
Light Spot Spot	71.0 72.9	N.S.	69.8 68.4	N.S.
Light Spot Tinge	71.0 74.9	$P<0.05$	69.8 69.5	N.S.
Spot Tinge	72.9 74.9	N.S.	68.4 69.5	N.S.

VAT ORANGE 2

Acceptance and Retention of Vat Orange 2 on the Basis of Grade of Cotton

Acceptance of Dye. The acceptance of Vat Orange 2 by the various grades of cotton varied from the usual pattern. In the bleached fabrics, Middling cotton accepted the highest percentage of dye (21.0 per cent), while Low Middling cotton accepted the lowest percentage (19.7 per cent). In the unbleached fabrics, however, this trend was reversed. Low Middling accepted the greatest level of this dye (20.3 per cent), while Middling cotton accepted the lowest amount (19.8 per cent). No significant differences were observed in the initial fabrics of Vat Orange 2 when comparisons of data were made on the basis of grades of cotton.

Fading during Light Exposure. After light fading, the findings revealed the fact that the unbleached Middling surpassed the unbleached Low Middling cotton with a significant difference ($P<0.01$); that unbleached Middling surpassed unbleached Strict Low Middling cotton by a highly significant difference ($P<0.001$); and that the reflectance of Low Middling showed slight evidence of being more subject to fading from light exposure than the Strict Low Middling ($P<0.10$). Bleached Middling cotton showed a significant difference in reflectance due to fading when compared to

the initial fabric ($P<0.05$); and the unbleached fabric during the same comparison exhibited a significant difference which was somewhat higher ($P<0.02$). Slight fading was noted also within the Low Middling grade of cotton ($P<0.10$).

Fading during Laundering. During laundering, bleached Middling cotton manifested a highly significant trend for fading ($P<0.001$). Strict Low Middling cotton showed the same trend ($P<0.01$). Low Middling cotton also was found to show a significant fading trend during laundering as was denoted by the highly significant difference between the reflectance values of the laundered and the non-laundered specimens ($P<0.001$). For the unbleached goods, Middling and Low Middling cottons showed a highly significant trend toward fading during laundering ($P<0.001$), whereas the degree of fading experienced by the Strict Low Middling cotton was of less significance ($P<0.01$).

Acceptance and Retention of Vat Orange 2 on the Basis of Color of Cotton

Acceptance of Dye. With respect to the original color of the cotton, it was found that the orange dye was accepted best by the White cotton (23.6 per cent), with least acceptance by Tinge cotton (16.6 per cent).

When observing the comparisons of the color of cotton in the initial bleached and dyed state of Vat Orange 2

the mean reflectance of bleached Spotted cotton surpassed the mean reflectance of bleached Tinge cotton by a significant difference ($P<0.05$). This was the only color which showed a significant difference in the initially dyed fabrics.

Fading during Light Exposure. When the reflectance values of the Vat Orange 2 fabric were compared on the basis of the original colors of the cotton, differences due to light exposure were not evident in the unbleached fabrics. Spot cotton contributed to a higher degree of fading than did White ($P<0.02$), whereas Light Spot ($P<0.01$) and Spot ($P<0.001$) showed more fading than did Tinge in the bleached and dyed fabrics.

Comparisons of the bleached and unbleached Vat Orange 2 fabrics gave evidence of the superior loss of color in the Spot color category favorable to the bleached fabrics ($P<0.05$).

Fading during Laundering. The bleached and the unbleached fabrics dyed with Vat Orange 2 evidenced fading that was significant in all four color categories when the reflectance values of the laundered fabrics were compared with the initial values. The degree of fading in most color groups was highly significant ($P<0.001$). Exceptions

were found in the Light Spot bleached and in the unbleached White and Spot colors where fading was not as defined ($P<0.01$).

Spot cotton showed a higher degree of fading during laundering than did Tinge cotton ($P<0.05$) for both bleached and unbleached samples. Light Spot cotton showed fading to a greater degree than Tinge cotton both in the bleached and unbleached fabrics. Other differences which were found to exist between the colors of cotton when fabrics were dyed with Vat Orange 2 and laundered can be noted in Summary F.

SUMMARY F

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LAUNDERED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT ORANGE 2)

Comparisons	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Light Spot	60.6 63.8	P<0.01	61.9 65.4	P<0.10
White Spot	60.6 63.6	P<0.02	56.0 58.7	P<0.02
Light Spot Tinge	63.8 61.1	P<0.01	65.4 61.0	P<0.02
Spot Tinge	63.6 61.1	P<0.05	63.2 61.0	P<0.05

VAT RED 10

Acceptance and Retention of Vat Red 10 on the Basis of Grade of Cotton

Acceptance of Dye. Vat Red 10 dye manifested little variation with respect to its acceptance in the bleached fabrics; Middling cotton showed the highest acceptance with an average of 23.7 per cent change during dyeing, while Low Middling cotton had the lowest acceptance of the dye, with an average of 20.3 per cent. In the unbleached cottons, Low Middling sustained the highest acceptance (30.4 per cent), whereas Middling had the least acceptance (25.4 per cent).

The only significant difference found in the initial fabrics, with reference to their acceptance of Vat Red 10 on the basis of grade of cotton, was that which appeared in the Low Middling grade. In comparing the bleached with the unbleached fabrics, the bleached Low Middling cotton was favored by a highly significant difference ($P<0.01$).

Fading during Light Exposure. No differences with reference to reflectance values were noted within the three grades of cotton when the bleached and dyed specimens exposed to 80 hours of sunlight were compared to their unexposed counterparts. A highly significant degree of fading occurred within the Low Middling grade of the fabrics which

were dyed in the unbleached state with Vat Red 10 ($P<0.001$). After exposure to light, the bleached fabrics in all three grades of cotton were superior in reflectance to the fabrics which were dyed without bleaching.

Fading during Laundering. Laundering produced highly significant degrees of fading within all three grades of bleached and unbleached cotton, as was evidenced by comparisons of the reflectance values of fabrics dyed with Vat Red 10 before and after laundering. After 25 laundering periods, no differences were found between the reactions of the three grades of the unbleached cotton. It was observed that in these fabrics the Middling ($P<0.02$) and the Low Middling ($P<0.01$) grades faded more than did the Strict Low Middling cotton.

Acceptance and Retention of Vat Red 10 on the Basis of Color of Cotton

Acceptance of Dye. When comparisons were made between the undyed and the dyed fabrics before exposing them to light or to laundering, with regard to color classes of cotton, Vat Red 10 dye was accepted best by bleached White cotton (28.8 per cent) and it was accepted least by bleached Tinge cotton (14.8 per cent). Interestingly enough, White cotton again accepted the most dye (33.8 per cent) while Tinge cotton accepted the least

(23.8 per cent). When statistically comparing the data of the Vat Red 10 fabrics with reference to the color class of cotton, no significant differences were found before fading.

Fading during Light Exposure. Significant differences between the respective colors of cotton were evident after 80 hours of exposure to light, both in the bleached and unbleached fabrics dyed with Vat Red 10. In the unbleached fabrics White, Light Spot, and Spot showed more fading than did Tinge, with differences significant at the levels shown in Summary G. With reference to the bleached fabrics, Spot showed more fading than Tinge ($P<0.05$), whereas there were slight indications of other differences. Within the Light Spot ($P<0.05$), Spot ($P<0.01$), and Tinge ($P<0.10$) categories of cotton, the bleached and dyed fabrics faded more from light exposure than did the unbleached and dyed fabrics. In the bleached category of fabrics, the reflectance of the respective colors of cotton was not affected significantly by light when the dyed and the faded specimens, within each color group, were compared with the dyed fabrics before exposure. Upon the basis of comparisons of the unbleached and the dyed fabrics, fading due to light exposure was evident in the White cotton ($P<0.01$), and a slight semblance of color change was also noted in the Spot color group ($P<0.10$).

Fading during Laundering. It was found that there was a significant difference in fading for all four color groups, both in the bleached and unbleached specimens.

In all color groups of the unbleached fabrics, comparisons between the initial and laundered specimens showed a highly significant degree of fading ($P<0.001$). Fading equivalent to that mentioned above was experienced by the White and Spot cottons in the bleached fabrics, however, the fading in the Light Spot and Tinge cottons was less significant ($P<0.01$).

Comparisons of the Vat Red 10 fabrics with reference to the bleached and unbleached data revealed a significant difference between the two treatments of fabrics in the Tinge cottons. In this instance, the fabrics which were bleached before dyeing exhibited the higher reflectance value ($P<0.01$).

SUMMARY G

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LIGHT FADED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT RED 10)

Comparisons	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Light Spot	51.1 52.6	P<0.10	50.7 50.5	N.S.
White Spot	51.1 52.8	P<0.10	50.7 50.9	N.S.
White Tinge	51.1 51.2	N.S.	50.7 48.3	P<0.01
Light Spot Spot	52.6 52.8	N.S.	50.5 50.9	N.S.
Light Spot Tinge	52.6 51.2	P<0.10	50.5 48.3	P<0.05
Spot Tinge	52.8 51.2	P<0.05	50.9 48.3	P<0.01

VAT VIOLET 13

Acceptance and Retention of Vat Violet 13 on the Basis of Grade of Cotton

Acceptance of Dye. Spectrophotometric readings disclosed the finding that bleached Middling cotton accepted the highest percentage of Vat Violet 13 dye, with a color change of 32.5 per cent. The readings also revealed that bleached Low Middling cotton underwent the lowest color change during dyeing, which was 30.7 per cent. In addition, the readings displayed the fact that, of the cottons dyed in the unbleached state, Strict Low Middling underwent the highest color change (36.9 per cent), and the Middling cotton showed the lowest change (32.8 per cent).

From statistical comparisons of the acceptance of Vat Violet 13 by the various grades of cotton, no significant differences were found in the initial fabric which was dyed but untreated. With respect to comparisons between grades of cotton, after pairing the bleached with the unbleached fabrics for acceptance tests, still no significant differences were found.

Fading during Light Exposure. After 80 hours of light exposure of Vat Violet 13 dyed fabrics, the mean reflectance of bleached Middling cotton surpassed the mean reflectance of bleached Strict Low Middling cotton by a

highly significant difference ($P<0.001$). This also was true for a comparison of the same unbleached fabrics ($P<0.001$). The mean reflectance of Low Middling cotton was higher than that of Strict Low Middling, both in the bleached and unbleached state ($P<0.01$). Only one other comparison revealed a difference in behavior during light exposure of Vat Violet 13; the mean reflectance of bleached Strict Low Middling cotton surpassed the mean reflectance of unbleached Strict Low Middling by a significant difference ($P<0.05$).

In evaluating the initial samples and those that had been exposed to light, there were no significant differences. Hence, fading was not evident.

Fading during Laundering. Following the 25 laundering treatments, comparisons were made between the tested samples and the initial samples dyed with Vat Violet 13, and in many cases there were numerous evidences of fading. In all comparisons involving grades of cotton, the dyed and laundered samples were lighter than the comparable non-laundered fabrics by distinctly significant differences. Low Middling (bleached) had a probability level of 0.01, and unbleached Strict Low Middling a probability of 0.02. In all remaining cases the other grades, bleached and unbleached, had highly significant changes during laundering ($P<0.001$).

Acceptance and Retention of Vat Violet 13 on the Basis of Color of Cotton

Acceptance of Dye. With regard to color classes of cotton, the spectrophotometric readings indicated that bleached White cotton absorbed the most violet dye (37.9 per cent), while the bleached Tinge cotton absorbed the least (27.6 per cent). For those unbleached fabrics which were dyed with Vat Violet 10 dye, the readings signified that White cotton accepted the most dye (37.9 per cent), and that Tinge cotton accepted the least (29.3 per cent).

In the statistical comparisons of the color classes of cotton, only bleached Light Spot cotton revealed a higher mean reflectance than unbleached Light Spot cotton ($P<0.02$); and unbleached Spot cotton had a higher reflectance than unbleached Light Spot cotton ($P<0.05$).

Fading during Light Exposure. Light exposure after 80 hours had little effect on the Vat Violet 13, and further study revealed that only unbleached Light Spot cotton showed a significant trend toward fading ($P<0.05$).

Fading during Laundering. After laundering tests were performed, Vat Violet 13 revealed fading in all color classes for both the bleached and the unbleached samples. See Summary H. It was also observed, when comparing the bleached to the unbleached cotton, that Tinge had a higher mean reflectance than White or Light Spot in the bleached state.

SUMMARY H

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LAUNDERED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT VIOLET 13)

Comparison	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Initial Laundered	44.0 50.0	P<0.02	44.0 51.4	P<0.01
Light Spot Initial Laundered	45.6 51.1	P<0.01	42.3 50.3	P<0.001
Spot Initial Laundered	46.0 52.0	P<0.05	44.2 51.1	P<0.01
Tinge Initial Laundered	45.0 53.4	P<0.001	44.0 51.9	P<0.01
White Tinge	50.0 53.4	P<0.01	51.4 51.8	N.S.
Light Spot Tinge	51.1 53.4	P<0.02	50.3 51.9	N.S.

VAT BLUE 6

Acceptance and Retention of Vat Blue 6 on the Basis of Grade of Cotton

Acceptance of Dye. The Vat Blue 6 dye showed a different trend in the rate of acceptance of dye by some of the unbleached cottons than was noted previously. Bleached Strict Low Middling cotton absorbed the highest percentage of dye (62.4 per cent), while bleached Low Middling cotton absorbed the lowest percentage of dye (61.5 per cent). However, both the unbleached Middling and the Strict Low Middling cotton sustained the same percentage of acceptance of dye (61.5 per cent). None of these differences were statistically significant. It also should be noted that the bleached fabrics manifested a very small difference (0.9 per cent) in their rate of acceptance. Tinge cotton had a 58.2 per cent level of acceptance.

In a statistical comparison of the performance of the grades of cotton with respect to acceptance of Vat Blue 6, the data indicated that the mean light reflectance readings were significantly different when comparing Strict Low Middling cotton to Low Middling cotton in the bleached and dyed fabrics. Here, the bleached Low Middling had the higher reflectance reading with a statistically significant difference ($P<0.05$). There were no other significant

differences in the comparisons made on the initial Vat Blue 6 samples in the bleached or unbleached state and the dyed samples.

Fading during Light Exposure. Light exposure produced fading to a significant degree only in bleached Middling cotton and in unbleached Strict Low Middling cotton when matched to their initial samples which had not been exposed to light ($P<0.01$ and $P<0.05$, respectively).

After comparing bleached Middling cotton to bleached Strict Low Middling cotton, a significant difference was observed in the mean reflectance values, with Middling cotton having the higher reflectance ($P<0.01$). A significant difference at the same level of significance was observed to favor bleached Middling over bleached Low Middling cotton. No differences were found in similar comparisons for the unbleached grades. When a comparison of bleached to unbleached Strict Low Middling cotton was made, however, the unbleached Strict Low Middling had a higher reflectance reading with a difference which was statistically significant ($P<0.01$). This same trend was observed in a comparison of bleached and unbleached Low Middling cotton with an even higher level of significance ($P<0.001$), favoring the higher reading on the unbleached fabric.

Fading during Laundering. The cotton fabrics dyed with Vat Blue 6 evidenced a highly significant trend of fading after laundering for all grades. The comparison between the laundered and non-laundered both in the bleached and unbleached fabrics showed highly significant differences. There were two groups which revealed significantly higher differences in reflectance readings in the unbleached state when compared to their bleached samples--Strict Low Middling ($P<0.001$) and Low Middling cotton ($P<0.01$). Another significant difference revealing higher mean reflectance before laundering was found in bleached Middling cotton over bleached Strict Low Middling cotton ($P<0.01$) and unbleached Low Middling over unbleached Strict Low Middling cotton ($P<0.05$).

Acceptance and Retention of Vat Blue 6 on the Basis of Color of Cotton

Acceptance of Dye. The evaluation of the acceptance of dye by color classes of cotton showed that bleached White cotton absorbed a higher percentage of dye (66.7 per cent) than any other of the cotton color classes. The evaluation also revealed that bleached Tinge cotton accepted a lower percentage of dye (58.4 per cent) than any other of the color classes. In the greige state, White cotton accepted the most dye (63.6 per cent) and Spotted cotton accepted the least dye (57.8 per cent).

When statistical comparisons were made on the initial Vat Blue 6 dyed fabrics, only one pair of color groups indicated any significant difference in light reflectance readings, namely bleached Tinge cotton had a higher reflectance than did bleached White cotton ($P<0.05$). No other significant differences were found on the initial fabrics.

Fading during Light Exposure. No significant differences were indicated in any of the color classes of cotton, bleached or unbleached, when comparisons were made as to the same initial, untreated samples after light exposure. Hence no fading was revealed in these cases. There were some significant differences in the means of White cotton and Spot cotton in comparing the bleached with the unbleached state. In both instances, the mean reflectance was higher in the unbleached goods ($P<0.01$). A comparison of White cotton to Spot cotton indicated that the Spot cotton had a higher reflectance in both bleached and unbleached samples ($P<0.05$). One other comparison indicated a significant difference in reflectance, namely bleached White cotton was surpassed by bleached Tinge cotton by a highly significant difference ($P<0.01$). No other differences were found in Vat Blue 6 due to the color of cotton.

Fading during Laundering. Laundering of Vat Blue 6 dyed samples revealed fading for every color group of cotton, when compared to the initial samples. See Summary I. There were significant differences in mean reflectance readings for the color group of cotton after laundering as noted in this summary. One other significant difference in mean reflectance which is not shown in the summary table was found in that a higher reading for Spot cotton in the unbleached state appeared when compared to its bleached state.

SUMMARY I

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED WITH DYED AND LAUNDERED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT BLUE 6)

Comparison	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Initial Laundered	23.6 30.5	P<0.001	25.8 34.0	P<0.001
Light Spot Initial Laundered	25.4 32.9	P<0.01	26.4 34.9	P<0.001
Spot Initial Laundered	25.9 33.1	P<0.001	28.2 37.0	P<0.01
Tinge Initial Laundered	25.8 34.3	P<0.001	28.5 33.5	P<0.001
White Light Spot	30.5 33.0	P<0.05	34.0 34.9	N.S.
White Spot	30.5 33.1	N.S.	34.0 37.0	P<0.05
White Tinge	30.5 34.2	P<0.001	34.0 33.5	N.S.
Light Spot Tinge	34.9 33.5	P<0.10	34.9 33.5	N.S.
Spot Tinge	33.1 34.2	P<0.10	37.0 33.5	P<0.01

VAT NAVY 18

Acceptance and Retention of Vat Navy 18 on the Basis of Grade of Cotton

Acceptance of Dye. According to tabulations based on the spectrophotometric readings, Middling cotton absorbed the highest percentage of Vat Navy 18 dye in the bleached group. The extent of acceptance for Middling cotton was 62.4 per cent; also in the bleached cottons, the lowest extent of acceptance was found for the Low Middling grade of cotton (55.0 per cent). The readings indicated that, of the unbleached group, Strict Low Middling cotton sustained a change of 64.6 per cent, which was the highest degree of acceptance. Middling cotton accepted the lowest percentage of dye (62.0 per cent) in the unbleached cottons.

According to the "t" tests performed on these data concerning Vat Navy 18, there were no significant differences in the initial, untreated vat-dyed fabrics, when grade of cotton was considered.

Fading during Light Exposure. Light exposure, after 80 hours, had little effect on this Navy 18 vat dye. There was a significant difference in mean reflectance between Strict Low Middling cotton in the bleached and unbleached state, with the bleached cotton having higher reflectance ($P<0.05$). The only other difference revealed

in light fading was that found in a comparison of unbleached Middling cotton with unbleached Strict Low Middling cotton and the unbleached Middling was favored with the higher reflectance ($P<0.05$).

Fading during Laundering. All grades of cotton treated with Vat Navy 18 disclosed a significant trend of fading both for bleached and unbleached specimens ($P<0.001$). A slight reflectance difference was revealed when comparing unbleached Middling cotton with unbleached Strict Low Middling cotton, with the Middling cotton displaying the higher reflectance ($P<0.10$). When Strict Low Middling cotton was compared in the bleached and unbleached states, a slightly significant difference was found to favor the bleached grade as exhibiting higher reflectance ($P<0.10$).

Acceptance and Retention of Vat Navy 18 on the Basis of Color of Cotton

Acceptance of Dye. In the grouping of fabrics according to color class, the examination disclosed very little difference in the levels of acceptance of dye both by the bleached and unbleached cottons. Bleached White cotton had the highest degree of acceptance (64.2 per cent); and bleached Tinge had the lowest level of acceptance (60.0 per cent). In the unbleached cotton, Vat Navy 18 was absorbed at nearly the same level as the bleached. There was little

difference in each of the highest and lowest levels of acceptance. White cotton accepted 65.0 per cent of the dye, while Tinge cotton accepted 60.8 per cent. No statistical differences were found in this initial fabric when considering the color class of cotton.

Fading during Light Exposure. No fading due to light exposure was evident in the Vat Navy 18 fabrics. A significant difference in reflectances was observed when bleached Spot cotton was compared with Light Spot cotton, with the former showing the higher reflectance ($P<0.01$). Also, bleached Spot cotton had a higher reflectance than bleached Tinge cotton by a difference which was significant ($P<0.05$). In the unbleached fabrics, White cotton had a higher reflectance than Tinge cotton by a significant difference ($P<0.02$). Bleached Spot also had a significantly higher reflectance than unbleached Spot ($P<0.05$). No other differences were found to be statistically significant when light exposure comparisons were made.

Fading during Laundering. All four color classes, both bleached and unbleached, exhibited a high level of fading, when the initial dyed sample was compared with the dyed and laundered specimens. When the laundered performance of bleached Spot cotton was compared with Tinge, the Spot faded somewhat more than the Tinge ($P<0.05$). The same comparison made in the unbleached fabric showed the

Spot to exceed the Tinge cotton with reference to fading during laundering by a slightly significant difference as can be noted in Summary J.

SUMMARY J

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LAUNDERED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT NAVY 18)

Comparisons	Bleached		Unbleached	
	Mean Reflectance	Probability	Mean Reflectance	Probability
White Light Spot	30.0 30.0	N.S.	30.9 30.6	N.S.
White Spot	30.0 30.8	N.S.	30.9 31.4	N.S.
White Tinge	30.0 29.5	N.S.	30.9 30.1	N.S.
Light Spot Spot	30.0 30.8	$P<0.20$	30.6 31.4	N.S.
Light Spot Tinge	30.0 29.5	$P<0.20$	30.6 30.1	N.S.
Spot Tinge	30.8 29.5	$P<0.05$	31.4 30.1	$P<0.10$

VAT GREEN 1

Acceptance and Retention of Vat Green 1 on the Basis of Grade of Cotton

Acceptance of Dye. For Vat Green 1, the difference in extent of acceptance of the dye by bleached and unbleached cotton was relatively minor. In the bleached fabrics which were dyed with Vat Green 1, it was noted that Strict Low Middling cotton absorbed the greatest amount of dye (63.0 per cent) and that Middling cotton absorbed the least amount of dye (60.9 per cent). In the greige state, the per cent of change in reflectance after dyeing was found to be the highest in Strict Low Middling (63.1 per cent) and to be the least in the Middling grade of cotton (60.5 per cent). A statistical analysis of the data by means of the "t" test applied to pairs of fabrics with respect to initial colors revealed the fact that no significant differences were found between the pairs.

Fading during Light Exposure. After 80 hours of light exposure, dyed Middling cotton when compared to Strict Low Middling revealed a higher reflectance both for the bleached and the unbleached cottons with the following significances of difference, $P<0.05$ and $P<0.02$, respectively. Another significant difference in the unbleached specimens was found in Middling cotton paired with Low Middling,

with Middling having the higher reflectance ($P<0.05$). Bleached Low Middling cotton revealed a higher mean reflectance than did bleached Strict Low Middling cotton, with a significant difference of $P<0.05$. When comparing bleached and unbleached samples, the only significant difference was found in the Low Middling grade cotton, with the bleached surpassing the non-bleached by a difference which was slightly significant ($P<0.10$).

Only one grade, Strict Low Middling, revealed a slight tendency for light fading when it was compared with the initial dyed fabric ($P<0.10$). This change occurred only in the bleached state.

Fading during Laundering. Laundered Vat Green 1 samples showed highly significant differences from the initial dyed fabric. This tendency was found in all three grades both for bleached and unbleached cottons, $P<0.001$ for all groups except bleached Middling which had a difference which was slightly less significant ($P<0.01$).

Acceptance and Retention of Vat Green 1 on the Basis of Color of Cotton

Acceptance of Dye. Regarding color classes, Vat Green 1 produced most variation of reflectance in bleached White cotton (65.9 per cent) and the least variation of reflectance in bleached Tinge cotton (56.6 per cent).

Unbleached White cotton accepted the most dye (65.2 per cent), while unbleached Tinge accepted the least (58.7 per cent).

A statistical analysis of the data revealed the finding that only one difference appeared in the initial fabrics and that was between bleached White cotton and bleached Spot cotton. This difference favored the Spot cotton with a higher mean reflectance ($P<0.01$). No other color groups of the cottons showed significant differences when compared by pairs.

Fading during Light Exposure. Vat Green 1, after 80 hours of light exposure, demonstrated some trend toward fading in the bleached state. Light Spot showed a difference which was slightly significant when compared to the initial fabric ($P<0.10$). Also, bleached Tinge showed a tendency toward light fading more than unbleached by a difference which was more highly significant than the previous comparison ($P<0.02$).

Only three comparisons made to determine differences in light fading were significant. The bleached Tinge cotton surpassed the bleached White cotton in light fading ($P<0.001$) in the unbleached cotton, while Light Spot cotton as well as Spot surpassed White cotton ($P<0.10$ and $P<0.01$, respectively).

Fading during Laundering. This green dye displayed fading in all color classes of cotton, both bleached and unbleached during laundering. The dyed specimens exhibited varying degrees of significance, when compared with the initial groups. See Summary K. Some variations in mean light reflectance may be observed also.

SUMMARY K

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LIGHT FADED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT GREEN 1)

Comparison	Bleached		Unbleached	
	Mean Reflectance	Probability	Mean Reflectance	Probability
White Initial Laundered	24.2 31.0	P<0.001	24.8 31.5	P<0.001
Light Spot Initial Laundered	24.5 32.0	P<0.001	25.1 32.7	P<0.001
Spot Initial Laundered	25.7 33.7	P<0.001	26.3 34.0	P<0.001
Tinge Initial Laundered	27.1 31.8	P<0.02	25.8 31.2	P<0.05
White Spot	31.0 33.7	P<0.01	31.5 34.0	P<0.01
Light Spot Spot	31.6 33.7	P<0.02	--	--
Spot Tinge	33.7 31.8	P<0.10	34.9 31.2	P<0.02

VAT OLIVE 13

Acceptance and Retention of Vat Olive 13 on the Basis of Grade of Cotton

Acceptance of Dye. According to the grade of cotton, Middling cotton showed the highest rate of acceptance of Vat Olive 13 both in the bleached and the unbleached fabrics. The bleached Middling cotton absorbed 72.9 per cent of dye, whereas the unbleached Middling absorbed 73.4 per cent of dye, with no significant difference between the two. There also was little difference in acceptance of this dye throughout the various cotton grades, with Strict Low Middling bleached cotton and Low Middling the lowest in this regard, accepting 71.5 and 71.6 per cent, respectively.

No significant differences were found when the "t" test was applied to pairs of initial fabrics and the dyed fabrics when considering the grades of cotton.

Fading during Light Exposure. There was a slightly significant difference in the bleached Middling cotton ($P<0.10$) when exposed to light fading and a difference of higher significance in the unbleached Middling cotton when it was compared to the initial samples. Hence fading took place in the Middling grade of cotton for fabrics dyed with Vat Olive 13. There were differences in mean reflectance of all three grades and bleached Low Middling grade had

a significantly higher reflectance than bleached Middling cotton ($P<0.02$). It also had a higher reflectance in the bleached state than in bleached Strict Low Middling with a difference of low significance ($P<0.10$). Middling and Strict Low Middling cotton had slightly higher significant differences in reflectance after light fading in the unbleached state compared to the bleached state, with a difference which was slightly significant ($P<0.10$).

Fading during Laundering. When considering the grades of cotton, the data revealed a highly significant difference ($P<0.001$) between the laundered and initial samples dyed with Vat Olive 13 for all grades both in the bleached and unbleached state. Only one other slightly significant difference was found in that there was a higher mean reflectance for Low Middling cotton when compared with Middling cotton ($P<0.10$).

Acceptance and Retention of Vat Olive 13 on the Basis of Color of Cotton

Acceptance of Dye. When judging the color absorbency of Vat Olive 13 in the bleached fabrics, it was observed that White cotton as well as Light Spot cotton had the same rate of change when dyed with Vat Olive 13. Each of the two cottons sustained a change of 73.2 per cent, while Spot cotton of the bleached group had a 71.0 per cent change.

In the unbleached group, White cotton maintained the highest rate of absorbency (73.2 per cent), and Spotted cotton the lowest rate of absorbency (70.4 per cent), although the difference in the two cases was not statistically significant.

In the statistical comparisons of acceptance of Vat Olive 13, the only significant difference involved a higher mean reflectance for Spot cotton in comparison with Tinge cotton ($P<0.05$).

Fading during Light Exposure. A highly significant difference was found between the initial and the light exposed bleached White cotton samples dyed with Vat Olive 13, indicating fading ($P<0.01$). Lesser differences were found in comparing unbleached Tinge cotton with bleached Light Spot, and Tinge cotton which reveal some light fading for these three color groups.

There were differences in mean reflectance for several groups as can be observed in Summary L. The other significant differences in mean reflectance for light fading which were not given in the summary were these: unbleached White cotton had a higher mean reflectance than bleached White cotton ($P<0.10$) and unbleached Spot had a higher reflectance than bleached Spot cotton ($P<0.05$).

SUMMARY L

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LIGHT FADED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT OLIVE 13)

Comparison	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Light Spot	17.8 19.1	N.S.	19.7 18.6	P<0.01
White Spot	17.8 19.3	N.S.	19.7 20.6	P<0.10
White Tinge	17.8 18.6	N.S.	19.7 19.1	P<0.10
Light Spot Spot	19.1 19.3	N.S.	18.6 20.6	P<0.001
Spot Tinge	19.3 18.6	N.S.	20.6 19.1	P<0.01

VAT BROWN 1

Acceptance and Retention of Vat Brown 1 on the Basis of Grade of Cotton

Acceptance of Dye. Evaluation of the spectrophotometric readings showed that both the bleached and the unbleached Strict Low Middling grade of cotton had the highest rates of acceptance of Vat Brown 1. The bleached Strict Low Middling absorbed 56.9 per cent of the dye and unbleached Strict Low Middling absorbed 57.5 per cent. In the low rates of acceptance of the dye, Low Middling cotton ranked the lowest (39.6 per cent) for the bleached group, and the Low Middling also ranked the lowest (41.1 per cent) for the unbleached group.

There were three light reflectance differences when the data were computed statistically for the performance of the grades of Vat Brown 1 dyed cotton in this initial state. Bleached Low Middling surpassed bleached Middling in mean reflectance by a significant difference ($P<0.05$); and unbleached Low Middling surpassed unbleached Strict Low Middling with a difference which was slightly significant ($P<0.10$). Middling cotton in the unbleached form surpassed the unbleached Strict Low Middling cotton with a significant difference ($P<0.05$). No other statistically significant differences were observed.

Fading during Light Exposure. The Vat Brown 1 dyed fabrics exhibited no apparent fading when the "t" test was applied to the light exposed specimens matched to the initial dyed fabrics. There were, however, some significant differences in mean light reflectance averages. The reflectance of Middling cotton surpassed the reflectance of Strict Low Middling cotton both in the bleached and unbleached fabrics with a difference in the first case which was significant ($P<0.05$), and in the second it was highly significant ($P\leq0.01$). The Low Middling cotton surpassed the Strict Low Middling cotton both in the bleached and the unbleached form, with a highly significant difference in both instances ($P<0.001$). Yet the Middling cotton surpassed the Low Middling cotton in the bleached state by a difference with a slightly lower significance ($P<0.01$).

Fading during Laundering. All three grades of cotton showed a tendency for fading when comparing the laundering samples to the initial dyed samples, with differences having a significance of varying degrees. Bleached Middling, bleached Low Middling and unbleached Middling cotton showed changes after fading which had a high level of significance ($P<0.001$); and the remainder had differences which were significant at a slightly lower level ($P<0.01$). When comparing the fabrics which had been bleached before dyeing to the unbleached fabrics, bleached Low Middling surpassed in mean light reflectance with a difference which had

a low probability of significance ($P<0.10$). Bleached Low Middling cotton dyed with Vat Brown 1 also surpassed bleached Strict Low Middling cotton by a difference which was slightly significant ($P<0.10$).

Laundered Vat Brown 1 dyed samples revealed further differences in light reflectance: bleached Low Middling cotton surpassed bleached Middling as well as bleached Strict Low Middling by differences which were significant with the following respective probabilities, $P<0.05$ and $P<0.001$). Also, unbleached Low Middling cotton surpassed unbleached Strict Low Middling by a highly significant difference ($P<0.01$). The final difference observed was that found after laundering in the higher reflectance of Middling cotton over Strict Low Middling cotton in the unbleached fabrics. The difference was extremely significant ($P<0.001$).

Acceptance and Retention of Vat Brown 1 on the Basis of Color of Cotton

Acceptance of Dye. In making evaluations according to color classes of cotton, the readings revealed the finding that Tinge cotton had the lowest rate of acceptance of the Vat Brown 1 dye both in the bleached and unbleached groups. The bleached Tinge cotton absorbed 34.1 per cent of the dye, while the unbleached Tinge cotton absorbed 35.0 per cent. The highest per cent acceptance of Vat Brown 1 was in the White class both for bleached (43.9 per cent) and unbleached cotton (45.9 per cent). According to the "t" test performed

on the data, no significant differences were observed in the initial cotton dyed with Vat Brown 1, according to the color of the cotton.

Fading during Light Exposure. No significant differences were found after matching the light exposed samples to the initial untreated, dyed samples. Hence no fading was evident. There were, however, variations in light reflectance readings to indicate the following as having higher readings: Light Spot cotton surpassed Spot in bleached goods by a significant difference ($P<0.05$); White surpassed Spot cotton in the bleached state by a slightly significant difference ($P<0.10$); Tinge surpassed White cotton in the unbleached state by a significant difference ($P<0.05$); Tinge surpassed Light Spot in the unbleached form by a highly significant difference ($P<0.01$); and Tinge surpassed Spot cotton both in the bleached and unbleached cotton by differences in each case which were highly significant ($P<0.01$).

Fading during Laundering. After exposure of the Vat Brown 1 fabrics to laundering, all color classes of cotton revealed fading in the bleached group except White, with the same tendency observed for all groups in the unbleached samples except Spot cotton, when comparing its initial to the treated samples. See Summary M. This summary also discloses changes in mean light reflectance readings for four bleached comparisons and two unbleached ones which indicates more changes for the bleached goods after dyeing.

SUMMARY M

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LAUNDERED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT BROWN 1)

Comparisons	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
White Initial Laundered	39.5 45.2	N.S.	38.1 44.7	P<0.01
Light Spot Initial Laundered	39.6 45.5	P<0.001	38.6 44.6	P<0.01
Spot Initial Laundered	37.5 43.3	P<0.02	38.4 42.8	N.S.
Tinge Initial Laundered	41.0 47.3	P<0.001	40.4 46.4	P<0.01
White Tinge	45.2 47.2	P<0.10	44.7 46.4	P<0.10
Light Spot Spot	45.5 43.3	P<0.05	44.6 42.8	N.S.
Light Spot Tinge	45.5 47.3	P<0.05	44.6 46.4	N.S.
Spot Tinge	43.3 47.3	P<0.001	42.8 46.4	P<0.02

VAT BLACK 9

Acceptance and Retention of Vat Black 9 on the Basis of Grade of Cotton

Acceptance of Dye. The tests revealed the fact that the Strict Low Middling grade of cotton absorbed the highest percentage of Vat Black 9 both in the bleached and the unbleached cottons. In this group, the Strict Low Middling cotton accepted 94.0 per cent of the dye, and in the unbleached group it accepted 92.0 per cent of the dye, with no significant difference in dye absorption by the two. Low Middling cotton in the bleached group accepted 91.6 per cent of the dye, while Middling cotton in the unbleached state accepted 91.4 per cent of the dye, again with no significant difference between the two types.

The statistical comparisons revealed only one difference in light reflectance of fabric dyed with Vat Black 9 for the grades of cotton. In this case Low Middling surpassed Strict Low Middling cotton by a significant difference ($P<0.05$).

Fading during Light Exposure. After 80 hours of light exposure, Vat Black 9 showed a slightly significant trend for fading in the bleached Middling and the bleached Strict Low Middling cottons ($P<0.10$). No significant

differences were found in the unbleached samples of other grades of cotton.

Fading during Laundering. Laundering for 25 periods caused fading to be observed in the Vat Black 9 for bleached Strict Low Middling cotton ($P<0.05$) and in unbleached Strict Low Middling ($P<0.10$). No other grades, however, whether bleached or unbleached showed a trend of fading after laundering. Middling cotton in the unbleached state revealed a higher mean reflectance than in the bleached cotton with a highly significant difference ($P<0.01$).

Middling cotton in the unbleached state also had a higher mean reflectance than did Strict Low Middling in the unbleached goods after laundering, with a difference which was highly significant ($P<0.01$). Low Middling cotton had a higher reflectance rating after laundering than Strict Low Middling cotton in the bleached state ($P<0.05$), as well as in the unbleached state ($P<0.10$).

Acceptance and Retention of Vat Black 9 on the Basis of Color of Cotton

Acceptance of Dye. Light Spot cotton showed the same degree of acceptance of dye (94.6 per cent) both in the bleached and unbleached fabrics. In the bleached group, Light Spot absorbed 94.6 per cent of dye which was the highest rate of acceptance for that group. Tinge cotton

in the bleached state absorbed the lowest percentage (93.4 per cent) of dye in this group, which did not differ significantly from the findings for Light Spot. Tinge color of cotton also had the lowest level of acceptance (92.9 per cent) in the unbleached fabrics. Light Spot absorbed the most dye (94.6 per cent) in the unbleached group, again showing a very narrow overall range of acceptance.

A statistical analysis of the initial fabrics according to the color of the cotton revealed four findings of mean reflectance which were significantly different. Bleached White cotton surpassed bleached Light Spot cotton by a difference which was slightly significant ($P<0.10$). Unbleached White cotton was surpassed by unbleached Light Spot with a difference which showed a higher level of significance ($P<0.05$). On the other hand, unbleached Light Spot cotton was surpassed in mean reflectance averages not only by unbleached Spot ($P<0.10$), but also by unbleached Tinge cotton ($P<0.02$).

Fading during Light Exposure. When Vat Black 9 was exposed to 80 hours of simulated sunlight in the Fade-Ometer, Light Spot cotton was the only color group which revealed fading, as noted in Summary N. This also was true both for bleached and unbleached samples. Changes in mean light reflectance as observed in this summary were

found only in the unbleached cotton. Two comparisons which were made in bleached against unbleached samples were found to be significant. Bleached Light Spot cotton surpassed unbleached Light Spot by a difference which was statistically significant ($P<0.05$), and unbleached Tinge surpassed bleached Tinge by a difference which also was significant with a somewhat higher level of significance ($P<0.02$).

Fading during Laundering. When Vat Black 9 was subjected to laundering, unbleached Spot, unbleached Light Spot and bleached Light Spot revealed fading in the comparisons made with initial fabrics with a slight significance ($P<0.10$) for the unbleached specimens and greater significance ($P<0.05$) for the bleached ones.

Again, the unbleached cotton revealed these significant differences in light reflectance: White cotton and Spot cotton surpassed Light Spot cotton ($P<0.01$), while Tinge cotton surpassed Light Spot cotton with a greater significance ($P<0.001$). One other variation revealed in the unbleached goods was the fact that Tinge surpassed Spot cotton in reflectance ($P<0.02$). When unbleached cotton was matched to bleached cotton, the unbleached White surpassed bleached White ($P<0.05$) and the unbleached Tinge surpassed the bleached Tinge ($P<0.01$).

SUMMARY N

STATISTICAL COMPARISONS OF REFLECTANCE MEASUREMENTS OF DYED AND LIGHT FADED FABRICS ON THE BASIS OF COLOR OF COTTON

(VAT BLACK 9)

Comparison	Bleached		Unbleached	
	Mean Reflectance	Proba-bility	Mean Reflectance	Proba-bility
Light Spot Initial Light Faded	3.7 4.2	P<0.02	3.7 4.0	P<0.05
White Light Spot	4.3 4.2	N.S.	4.3 4.0	P<0.05
White Tinge	4.3 4.2	N.S.	4.3 4.6	P<0.05
Light Spot Spot	4.2 4.4	N.S.	4.0 4.5	P<0.001
Light Spot Tinge	4.2 4.2	N.S.	4.0 4.6	P<0.001

DIRECT DYES

Summaries O through X report the per cent variation in reflectance of the Direct Dyes of this study. For determining the acceptance of the dye by the fabric in question, the average of spectrophotometric readings was used. The difference between the original, undyed sample specimen and the dyed sample was computed to determine the per cent change in reflectance as a result of dyeing. The same procedure was used to determine the average change in light reflectance readings after light fading and laundering as was followed with the vat dyes. These changes are referred to only by percentage differences between the undyed and the dyed fabric specimens in the following discussion.

DIRECT YELLOW 98

Acceptance and Retention of Direct Yellow 98 on the Basis of Grade of Cotton

Acceptance of Dye. The range of acceptance of the cotton which was bleached and dyed with Direct Yellow 98 varied from 39.1 per cent for Low Middling cotton to 71.0 per cent for Middling grade of cotton (see Summary O). There was only a slight difference between Middling cotton and Strict Low Middling with respect to acceptance of this dye. It would be concluded that the Middling and Strict Low

Middling grades of cotton had better dye acceptance than did the Low Middling grade, when bleaching preceded dyeing.

Fading during Light Exposure. The unbleached fabrics had minor differences among the grades with respect to changes in the percentages of reflectance from 20.2 per cent for Low Middling cotton to 22.0 per cent for Middling cotton. It was decided that the grade of the cotton had little effect on the acceptance of this hue, if it was dyed in the greige state.

The retention of this dye after 80 hours of light fading cannot be evaluated accurately by the reflectance readings, since the levels of difference in the fabric before and after dyeing in all cases were less than the initial readings. Because of chemical changes in the dye, the faded samples appeared darker after light exposure than before, and hence gave low readings of -1.0 per cent for bleached Middling to -5.6 per cent for bleached Strict Low Middling. The fabrics dyed in the greige state had lower readings, ranging from -0.6 per cent for Low Middling to -5.8 per cent for Strict Low Middling cottons.

Fading during Laundering. Laundered samples after 20 laundering periods did not show the same trend of negative readings. The bleached specimens revealed changes in reflectance of 25.3 per cent for Low Middling to 32.3 per cent for Middling cottons. Hence the greatest loss of dye was found

in the Middling grade and the smallest loss of this hue fell in the Strict Low Middling grade.

Lesser differences were evident in the unbleached and dyed samples. Low Middling cotton had a change of 29.9 per cent and Middling cotton had a change of 35.1 per cent, which produced the same trend as the bleached samples.

Acceptance and Retention of Direct Yellow 98 on the Basis of Color of Cotton

Acceptance of Dye. Direct Yellow 98 was accepted by the color classes by a difference ranging from 13.1 per cent for White to 39.0 per cent for Spotted Cotton. Because of the fact that Spotted cotton has a yellow shading, this probably influenced the appearance as well as the spectrophotometric readings of fabrics colored with this direct dye. For the unbleached cotton, there were minor differences in the various color classes with Light Spot cotton having the lowest acceptance (19.7 per cent), and Tinge having the highest (24.4 per cent).

Fading during Light Exposure. Samples subjected to 80 hours of light fading revealed no difference between bleached White and bleached Light Spot cotton with both having a negative percentage reflectance change of 2.6 per cent. The other color classes varied from -1.5 per cent for Tinge to -5.9 per cent for Spot cotton, in the bleached state.

The unbleached cotton had the highest reading for Light Spot (4.0 per cent change), with the lowest reading for White (-6.1 per cent). This does not reflect the true loss of color due to fading, since the specimens darkened in hue as fading progressed, resulting in lower readings. This probably was a result of changes in the chemical structure of some of the components of this dye.

Fading during Laundering. Twenty-five launderings produced definite changes in the yellow with bleached White having the highest color loss (31.0 per cent change from the original), and bleached Spot cotton having the least (26.4 per cent). On the other hand, Tinge showed the least color loss in unbleached samples (39.2 per cent) as compared to White in the unbleached state (30.0 per cent).

SUMMARY O

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT YELLOW 98)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	71.0	-1.0	32.3
Strict Low Middling	70.5	-5.6	26.3
Middling	71.0	-1.0	32.3
Low Middling	39.1	-4.7	25.5
Strict Low Middling	70.5	-5.6	26.3
Low Middling	39.1	-4.7	25.5
Unbleached			
Middling	22.0	-2.8	35.1
Strict Low Middling	22.9	-5.8	33.8
Middling	22.0	-2.8	35.1
Low Middling	20.2	-0.6	29.9
Strict Low Middling	22.9	-5.8	33.8
Low Middling	20.2	-0.6	29.9

SUMMARY O--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT YELLOW 98)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White	13.1	-2.6	31.0
Light Spot	36.8	-2.6	27.2
White	13.1	-2.6	31.0
Spot	39.0	-5.9	26.4
White	13.1	-2.6	31.0
Tinge	24.1	-1.5	27.2
Light Spot	36.8	-2.6	27.2
Spot	39.0	-5.9	26.4
Light Spot	36.8	-2.6	27.2
Tinge	24.1	-1.5	27.2
Spot	39.0	-5.9	26.4
Tinge	24.1	-1.5	27.2
Unbleached			
White	21.9	-6.1	30.0
Light Spot	19.7	+4.0	32.6
White	21.9	-6.1	30.0
Spot	21.2	-4.0	36.0
White	21.9	-6.1	30.0
Tinge	24.4	-2.6	39.2
Light Spot	19.7	+4.0	32.6
Spot	21.2	-4.0	36.0
Light Spot	19.7	+4.0	32.6
Tinge	24.4	-2.6	39.2
Spot	21.2	-4.0	36.0
Tinge	24.4	-2.6	39.2

DIRECT ORANGE 61

Acceptance and Retention of Direct Orange 61 on the Basis of Grade of Cotton

Acceptance of Dye. The acceptance of Direct Orange 61 by the bleached samples as recorded in Summary P verifies the fact that Middling cotton absorbed the greatest amount of dye of any of the grades (30.5 per cent), when grades of cotton were compared. On the other hand, bleached Low Middling cotton accepted the least amount of dye (23.2 per cent). Low Middling cotton had the greatest acceptance of dye in the unbleached state (39.6 per cent) and Strict Low Middling cotton had the least acceptance in this state (32.2 per cent).

Fading during Light Exposure. Light fading had an adverse effect on this Orange dye since some chemical change in the dye caused darkened colors during light exposure. As a result, some readings were lower after light fading than before they were exposed to light. Visual inspection detected a trend toward a great amount of fading, together with a change of hue. In the bleached goods, Middling cotton showed a change of 0.8 per cent due to light fading, while Low Middling cotton showed a negative 0.4 per cent change. In the unbleached samples, Low Middling cotton had the highest color loss (2.4 per cent) and Middling had the least color loss as a result of light fading (-1.7 per cent).

Fading during Laundering. Laundering tests revealed a high percentage of color loss due to fading, with Strict Low Middling losing the greatest level of dye in the bleached state (50.2 per cent), and Low Middling losing the lease amount of dye in this state (46.4 per cent). For the unbleached samples, Middling cotton lost the largest percentage of dye (64.3) and Strict Low Middling lost the least dye (52.2 per cent).

Acceptance and Retention of Direct Orange 61 on the Basis of Color of Cotton

Acceptance of Dye. When comparing color classes of cotton it was found that Spot or spotted cotton accepted the greatest amount of dye in the bleached state (30.8 per cent), as well as in the unbleached state (39.6 per cent). The least amount of dye was absorbed by Tinge cotton in the bleached samples (14.6 per cent) and in the unbleached condition (26.5 per cent).

Fading during Light Exposure. Light fading showed a negative trend in these readings for color classes, as it did for grades of cotton. Bleached Light Spot revealed a low percentage of change of 1.4 per cent and it had a high change of 2.2 per cent for the unbleached specimens. Tinge had the lowest readings denoting the least amount of fading.

The bleached goods sustained a change of -6.0 per cent and the unbleached had a negative change of 6.1 per cent.

Fading during Laundering. Laundering showed a definite trend toward fading for all color classes of cotton, with changes in reflectance from a high loss of dye in the bleached Spotted cotton (53.2 per cent) to the lowest loss of dye in the bleached Tinge (35.6 per cent).

The unbleached fabrics lost the least amount of dye in the Tinge type of cotton (47.9 per cent) and the greatest amount in the White cotton (63.0 per cent).

SUMMARY P

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT ORANGE 61)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	30.5	0.8	50.0
Strict Low Middling	25.3	0.2	50.2
Middling	30.5	0.8	50.0
Low Middling	23.2	-0.4	46.4
Strict Low Middling	25.3	0.2	50.2
Low Middling	23.2	-0.4	46.4
Unbleached			
Middling	37.5	-1.7	64.3
Strict Low Middling	32.2	-0.9	52.2
Middling	37.5	-1.7	64.3
Low Middling	39.6	2.4	52.9
Strict Low Middling	32.2	-0.9	52.2
Low Middling	39.6	2.4	52.9

SUMMARY P--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS (DIRECT ORANGE 61)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White	30.5	-1.2	47.1
Light Spot	28.4	+1.4	52.8
White	30.5	-1.2	47.1
Spot	30.8	-4.1	53.2
White	30.5	-1.2	47.1
Tinge	14.6	-6.0	35.6
Light Spot	28.4	+1.4	52.8
Spot	30.8	-4.1	53.2
Light Spot	28.4	+1.4	52.8
Tinge	14.6	-6.0	35.6
Spot	30.8	-4.1	53.2
Tinge	14.6	-6.0	35.6
Unbleached			
White	37.5	-0.9	63.0
Light Spot	32.2	+2.2	55.5
White	37.5	-0.9	63.0
Spot	39.6	+1.0	59.0
White	37.5	-0.9	63.0
Tinge	26.5	-6.1	47.9
Light Spot	32.2	+2.2	55.5
Spot	39.6	+1.0	59.0
Light Spot	32.2	+2.2	55.5
Tinge	26.5	-6.1	47.9
Spot	39.6	+1.0	59.0
Tinge	26.5	-6.1	47.9

DIRECT RED 184

Acceptance and Retention of Direct Red 184 on the Basis of Grade of Cotton

Acceptance of Dye. According to Summary Q, the tendency for acceptance of Direct Red 184 was favored for Low Middling cotton in bleached fabrics (20.2 per cent), with the tendency for the least acceptance being for Strict Low Middling cotton (26.5 per cent). In unbleached fabrics, Strict Low Middling cotton experienced the best acceptance (40.1 per cent), while Low Middling cotton had the poorest acceptance (34.6 per cent). White cotton rated second in both classifications.

Fading during Light Exposure. On surveying the results of light fading tests, the findings for bleached cotton indicated that most fading occurred in the Low Middling class of cotton (18.3 per cent), and the least fading in the Strict Low Middling cotton class (8.6 per cent). Again, Middling rated second in both instances.

Fading during Laundering. After laundering evaluations, Middling rated highest in color loss for the bleached specimens (20.8 per cent), yet Strict Low Middling cotton rated lowest in this classification (11.8 per cent). The unbleached fabrics had most color loss for Strict Low Middling cotton (21.8 per cent), with least color loss for

Middling cotton (20.8 per cent). In all cases, laundering caused more fading than was caused by exposure to light.

Acceptance and Retention of Direct Red 184 on the Basis of Color of Cotton

Acceptance of Dye. In analyzing data for the bleached specimens, White cotton was found to have the best acceptance of dye (33.4 per cent) and Tinge cotton had the poorest acceptance (24.6 per cent). In unbleached fabrics, Tinge had the best acceptance (39.2 per cent) and Spot the poorest acceptance (35.9 per cent).

Fading during Light Exposure. After light fading, the red dye lost the greatest amount of color from bleached Spot cotton (21.4 per cent) and Light Spot cotton lost the least color (15.5 per cent) in the bleached state.

Fading during Laundering. In unbleached samples, Tinge demonstrated the greatest fading as a result of laundering (25.7 per cent), and Light Spot cotton had the least (19.7 per cent).

There appeared to be no pattern with respect to these comparisons concerning grades or colors of cotton other than the fact that laundering caused more fading than did exposure to light.

SUMMARY Q

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT RED 184)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	27.7	9.6	20.8
Strict Low Middling	26.5	8.6	11.8
Middling	27.7	9.6	20.8
Low Middling	29.2	18.3	20.6
Strict Low Middling	26.5	8.6	11.8
Low Middling	29.2	18.3	20.6
Unbleached			
Middling	38.2	9.3	20.8
Strict Low Middling	40.0	8.8	21.8
Middling	38.2	9.3	20.8
Low Middling	34.6	6.9	20.9
Strict Low Middling	40.0	8.8	21.8
Low Middling	34.6	6.9	20.9

SUMMARY Q--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT RED 184)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White	33.4	13.4	17.8
Light Spot	27.1	11.5	15.5
White	33.4	13.4	17.8
Spot	30.6	11.9	21.4
White	33.4	13.4	17.8
Tinge	24.6	9.6	17.9
Light Spot	27.1	11.5	15.5
Spot	30.6	11.9	21.4
Light Spot	27.1	11.5	15.5
Tinge	24.6	9.6	17.9
Spot	30.6	11.9	21.4
Tinge	24.6	9.6	17.9
Unbleached			
White	38.9	14.3	19.9
Light Spot	36.5	6.2	19.7
White	38.9	14.3	19.9
Spot	35.9	3.5	20.1
White	38.9	14.3	19.9
Tinge	39.2	8.7	25.7
Light Spot	36.5	6.2	19.7
Spot	35.9	3.5	20.1
Light Spot	36.5	6.2	19.7
Tinge	39.2	8.7	25.7
Spot	35.9	3.5	20.1
Tinge	39.2	8.7	25.7

DIRECT VIOLET 47

Acceptance and Retention of Direct Violet 47 on the Basis of Grade of Cotton

Acceptance of Dye. The per cent of change of reflectance for bleached fabric colored with Direct Violet 47, as seen in Summary R, ranged from 27.9 per cent for Strict Low Middling cotton to 34.3 per cent for Low Middling cotton. These data indicate that Low Middling cotton accepted a higher percentage of this dye, whereas Strict Low Middling cotton had the lowest percentage of acceptance.

In the unbleached state, higher levels of change were found in reflectance averages, with Middling cotton exhibiting a change of 34.2 per cent and Strict Low Middling cotton a 40.5 per cent change.

Fading during Light Exposure. After evaluating the fabric following 80 hours of light fading, the Low Middling cotton evinced the least color loss, with a change of -3.9 per cent, as compared to the bleached Middling cotton with the highest color loss (2.4 per cent). The unbleached goods which were colored with this dye showed that Middling cotton sustained no color loss, and that Low Middling cotton underwent the highest color loss of the cottons (4.6 per cent). This did not indicate the actual change resulting from light exposure, since visual inspection indicated a definite loss of hue.

Fading during Laundering. The laundering test disclosed differences of 48.4 per cent for Strict Low Middling to 57.7 per cent for Low Middling cotton in the bleached and dyed fabric. This would indicate that bleached Strict Low Middling cotton showed the least amount of fading after laundering; and that bleached Low Middling cotton faded to the greatest extent.

In the cotton fabric which was dyed with Direct Violet 47 in the greige state, Middling cotton sustained the least amount of fading (53.7 per cent) and Low Middling cotton a somewhat larger degree of fading (58.7 per cent).

Acceptance and Retention of Direct Violet 47 on the Basis of Color of Cotton

Acceptance of Dye. Direct Violet 47 data showed that bleached Tinge cotton maintained the lowest acceptance of this dye (29.4 per cent), while bleached White cotton experienced the best acceptance (32.0 per cent).

In the unbleached fabrics, the dye was accepted best by Tinge cotton (43.2 per cent), with Light Spot cotton displaying the poorest acceptance (32.2 per cent).

Fading during Light Exposure. After 80 hours of light exposure, the fabrics dyed with Direct Violet 47 underwent only small changes, with bleached Light Spot

cotton undergoing the smallest per cent of change (1.0 per cent) or the least color loss of dye. Tinge cotton sustained the greatest change (4.7 per cent) for the greatest loss of color. In the Violet-dyed greige goods, the readings tend to favor White cotton for the least fading (3.7 per cent), with Tinge cotton showing the most color change (10.5 per cent). Again, visual inspection was not entirely consistent in findings with the laboratory tests, when examining the dyed and faded specimens in comparison with the untreated samples.

Fading during Laundering. Laundering tests with the bleached fabrics produced results which favored White cotton for least color change (45.0 per cent) and Tinge cotton with the highest change (64.0 per cent). In the unbleached, dyed cotton, the greatest fading occurred again for Tinge cotton with a 65.4 per cent change. Yet White cotton revealed the least fading, with readings showing only a 37.2 per cent change.

SUMMARY R

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT VIOLET 47)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	31.4	2.4	55.0
Strict Low Middling	27.9	2.1	48.4
Middling	31.4	2.4	55.0
Low Middling	34.3	-3.9	57.7
Strict Low Middling	27.9	2.1	48.4
Low Middling	34.3	-3.9	57.7
Unbleached			
Middling	34.2	0.0	53.7
Strict Low Middling	40.5	2.5	54.4
Middling	34.2	0.0	53.7
Low Middling	35.2	4.6	58.7
Strict Low Middling	40.5	2.5	54.4
Low Middling	35.2	4.6	58.7

SUMMARY R--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS (DIRECT VIOLET 47)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White Light Spot	32.0 31.6	2.1 1.0	45.0 54.8
White Spot	32.0 31.7	2.1 2.6	45.0 51.4
White Tinge	32.0 29.4	2.1 4.7	45.0 64.0
Light Spot Spot	31.6 31.7	1.0 2.6	54.8 51.4
Light Spot Tinge	31.6 29.4	1.0 4.7	54.8 64.0
Spot Tinge	31.7 29.4	2.6 4.7	51.4 64.0
Unbleached			
White Light Spot	38.2 32.2	3.7 3.9	38.0 55.8
White Spot	38.2 33.2	3.7 4.5	38.0 55.1
White Tinge	38.2 43.2	3.7 10.5	38.0 65.4
Light Spot Spot	32.2 33.2	3.9 4.5	55.8 55.1
Light Spot Tinge	32.2 43.2	3.9 10.5	55.8 65.4
Spot Tinge	33.2 43.2	4.5 10.5	55.1 65.4

DIRECT BLUE 14

Acceptance and Retention of Direct Blue 14 on the Basis of Grade of Cotton

Acceptance of Dye. As observed from Summary S the range of acceptance of this hue varied from 65.1 per cent for the bleached Low Middling cotton to 70.0 per cent for the bleached Middling. The bleached Strict Low Middling exhibited a slightly higher percentage of acceptance of the color than did the Low Middling. In the unbleached fabric, the percentage ranged from 66.7 per cent for the Low Middling to 67.8 for the Middling cotton. The Low Middling rated lowest in acceptance, although there was little difference between the Low Middling and Strict Low Middling cotton. The differences were lower for the unbleached fabrics than for the bleached fabrics.

Fading during Light Exposure. As observed in this summary, after 80 hours of light fading, the variation between the original dyed sample and the dyed and faded sample ranged from 12.3 to 32.5 per cent with the Middling cotton displaying the greatest loss of color. There was only a slight difference between Strict Low Middling and Low Middling cotton.

In the unbleached state, the trend was for Low Middling cotton to have the highest color loss of the hue

with a per cent variation of 19.6. Strict Low Middling had the lowest per cent variation (14.0) for light fading and Middling cotton had 15.1 per cent variation.

Fading during Laundering. After 25 laundering periods, the bleached and dyed samples had a much higher per cent variation in reflectance, denoting more color loss from laundering than from light fading. The variations ranged from 92.2 for Low Middling to 100.5 for Middling cotton. There was a slight difference between Strict Low Middling and Low Middling cotton with Low Middling having the best retention of Direct Blue 14. In the unbleached fabric, the readings ranged from 51.1 to 95.5 with Strict Low Middling cotton showing the highest degree of fading. There was little difference between Middling and Strict Low Middling cotton but much more variation between these two groups and Low Middling cotton.

Acceptance and Retention of Direct Blue 14 on the Basis of Color of Cotton

Acceptance of Dye. When comparing color classes of the samples, the acceptance of the Direct Blue 14 dye was found to range in per cent variations from 64.5 for the Tinge to 70.2 for the White cotton. Little difference was found between Light Spot and Spot with the widest variation found between White and Tinge cotton. In the greige state,

the variations ranged from 64.6 to 70.2 per cent. The same general trend was evident for the greige goods as found in the bleached fabrics, except for a much wider variation between Spot and Tinge.

Fading during Light Exposure. After light fading the per cent variations ranged from 11.4 for Light Spot to 23.1 for Tinge cotton. In the greige state, variations ranged from 12.8 for Spot to 19.5 for Tinge. Tinge lost more hue in this test than any other color classification.

Fading during Laundering. Higher variations were found for the laundering test and Tinge lost more color in the bleached state (105.9 per cent) as well as in unbleached (98.2). White cotton faded least in the bleached state (96.7) and Spot faded least in the unbleached state (93.1).

SUMMARY S

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT BLUE 14)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	70.0	32.5	100.5
Strict Low Middling	65.8	12.3	92.5
Middling	70.0	32.5	100.5
Low Middling	65.1	12.5	92.2
Strict Low Middling	65.8	12.3	92.5
Low Middling	65.1	12.5	92.2
Unbleached			
Middling	67.8	15.1	95.4
Strict Low Middling	66.7	14.0	95.9
Middling	67.8	15.1	95.4
Low Middling	67.1	19.6	51.1
Strict Low Middling	66.7	14.0	95.9
Low Middling	67.1	19.6	51.1

SUMMARY S--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT BLUE 14)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White Light Spot	70.2 66.3	22.3 11.4	96.7 97.8
White Spot	70.2 66.5	22.3 18.8	96.7 98.6
White Tinge	70.2 64.5	22.3 23.1	96.7 105.9
Light Spot Spot	66.3 66.5	11.4 18.8	97.8 98.6
Light Spot Tinge	66.3 64.5	11.4 23.1	97.8 105.9
Spot Tinge	66.5 64.5	18.8 23.1	98.6 105.9
Unbleached			
White Light Spot	70.2 66.3	18.5 14.4	97.2 95.6
White Spot	70.2 67.3	18.5 12.8	97.2 93.1
White Tinge	70.2 64.6	18.5 19.5	97.2 98.2
Light Spot Spot	66.3 67.3	14.4 12.8	95.6 93.1
Light Spot Tinge	66.3 64.6	14.4 19.5	95.6 98.2
Spot Tinge	67.3 64.6	12.8 19.5	93.1 98.2

DIRECT NAVY 252

Acceptance and Retention of Direct Navy 252 on the Basis of Grade of Cotton

Acceptance of Dye. Summary T presents data concerning Direct Navy 252. The acceptance of this dye by the various classes of fabrics in the bleached group ranged from 80.4 per cent for Strict Low Middling cotton to 77.7 per cent for Low Middling. In the greige state, the greatest acceptance was found in the Strict Low Middling grade of cotton (80.6 per cent), with a slightly lower acceptance in the Low Middling grade (80.3 per cent). Thus, Direct Navy 252 dye appeared to have the better acceptance of color in the lower grades of cotton.

Fading during Light Exposure. With regard to the light fading tests made on the cotton, the Low Middling cotton lost the greatest amount of color (16.2 per cent), while White cotton lost the least color in the bleached fabric. In the griege state, Strict Low Middling cotton faded the most (24.8 per cent), while Low Middling faded the least (22.6 per cent).

Fading during Laundering. Laundering induced much higher losses of color than light fading, since bleached Middling cotton sustained a 71.9 per cent loss of color, and unbleached Strict Low Middling cotton underwent a 24.8 per

cent loss. The smallest losses occurred in bleached Low Middling (16.2 per cent) and unbleached Low Middling cotton (22.5 per cent).

Acceptance and Retention of Direct Navy 252 on the Basis of Color of Cotton

Acceptance of Dye. Light Spot cotton accepted this dye extremely well, with the highest acceptance of dye being 80.3 per cent in the bleached state and 81.2 per cent in the unbleached state. The least acceptance of Direct Navy 252 was that exhibited by the Tinge grade of cotton, with a 78.9 per cent acceptance for the bleached cotton and 80.2 per cent for the unbleached cotton.

Fading during Light Exposure. According to spectrophotometric readings, Direct Navy 252 also evinced negative results after the light fading test. The recordings ranged from -3.0 per cent for Light Spot cotton to -8.8 per cent for Spotted cotton in the bleached state. Again the spectrophotometric test did not depict the true fading of the fabric, since the eye could detect more change than the test showed. In the unbleached state, the Tinge grade of cotton had a positive change of 8.9 per cent; while the Spot grade had a negative 5.2 per cent change.

The ultraviolet rays of the light fading test may have caused some chemical reaction in the dye. Consequently,

this chemical reaction probably was responsible for the misleading readings, since the fabrics showed much more fading by visual inspection than by the spectrophotometric test.

Fading during Laundering. The highest degree of fading incurred from laundering was found to be the bleached Tinge (21.4) as well as the unbleached Tinge (30.9). The lowest percentage of variation was observed in Spot cotton for both the bleached (10.2) and unbleached (17.8) state.

SUMMARY T

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT NAVY 252)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	79.4	7.2	71.9
Strict Low Middling	80.4	16.0	16.8
Middling	79.4	7.2	71.9
Low Middling	77.7	16.2	16.2
Strict Low Middling	80.4	16.0	16.8
Low Middling	77.7	16.2	16.2
Unbleached			
Middling	80.6	22.9	22.9
Strict Low Middling	80.6	24.8	24.8
Middling	80.6	22.9	22.9
Low Middling	80.3	22.6	22.6
Strict Low Middling	80.6	24.8	24.8
Low Middling	80.3	22.6	22.6

SUMMARY T--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT NAVY 252)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White Light Spot	80.2 80.3	-4.3 -3.0	15.0 20.2
White Spot	80.2 79.4	-4.3 -8.8	15.0 10.2
White Tinge	80.2 78.9	-4.3 -3.0	15.0 21.4
Light Spot Spot	80.3 79.4	-3.0 -8.8	20.2 10.2
Light Spot Tinge	80.3 78.9	-3.0 -3.0	20.2 21.4
Spot Tinge	79.4 78.9	-8.8 -3.0	10.2 21.4
Unbleached			
White Light Spot	80.8 81.2	-2.9 +2.3	21.3 26.6
White Spot	80.8 79.7	-2.9 -5.2	21.3 17.8
White Tinge	80.8 80.2	-2.9 +8.9	21.3 30.9
Light Spot Spot	81.2 79.7	+2.3 -5.2	26.6 17.8
Light Spot Tinge	81.2 80.2	+2.3 +8.9	26.6 30.9
Spot Tinge	79.7 80.2	-5.2 +8.9	17.8 30.9

DIRECT GREEN 68

Acceptance and Retention of Direct Green 68 on the Basis of Grade of Cotton

Acceptance of Dye. Summary U signifies that Middling cotton accepted the largest level of this dye in the bleached state (60.4 per cent), and that Strict Low Middling accepted the least dye (51.8 per cent) of this type in this state. In the unbleached group, however, Strict Low Middling cotton accepted the most dye (72.4 per cent), while Middling accepted the least dye (66.1 per cent).

Fading during Light Exposure. Where fading occurred due to light exposure, Strict Low Middling cotton exhibited the greatest loss of dye in the bleached goods (35.5 per cent), whereas bleached Middling sustained the least loss of dye (26.5 per cent). In the greige state, Low Middling cotton lost the most of this dye (39.1 per cent) and Middling lost the least dye (26.1 per cent).

Fading during Laundering. Laundering caused color losses similar to light fading. Bleached Strict Low Middling cotton underwent the greatest loss of dye (35.4 per cent), and bleached Low Middling sustained the least color loss (18.7 per cent).

The Low Middling grade of cotton faded the most in the unbleached fabrics (40.1 per cent), and the Middling

grade faded the least for the cotton in the unbleached state (34.6 per cent).

Acceptance and Retention of Direct Green 68 on the Basis of Color of Cotton

Acceptance of Dye. In comparing the acceptance of this dye according to the color of the cotton, it was evident that Spotted cotton demonstrated the highest acceptance in the bleached cottons (61.6 per cent), while White cotton showed the lowest acceptance (50.1 per cent) in the fabric which had been bleached.

In the unbleached group, White cotton manifested the highest acceptance of this dye (64.1 per cent), and Tinge cotton showed the lowest acceptance (57.6 per cent).

Fading during Light Exposure. Fading as the result of exposure to light was responsible for the greatest change in White cotton (40.6 per cent) for bleached goods, and for the least change in bleached Light Spot cotton (24.0 per cent).

In the unbleached cottons, Spotted cotton experienced the most change (6.2 per cent) and Light Spot cotton showed the least change (0.4 per cent).

Fading during Laundering. Laundering caused a greater degree of color loss in cotton than did light fading.

Laundering caused the following levels of fading in the bleached fabrics: Spotted cotton showed the greatest change (33.2 per cent); Light Spot cotton had the least change (13.3 per cent); unbleached White cotton lost the most dye (64.0 per cent), and unbleached Tinge lost the least dye (57.6 per cent).

SUMMARY U

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT GREEN 68)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	60.4	26.5	25.0
Strict Low Middling	51.8	35.5	35.4
Middling	60.4	26.5	25.0
Low Middling	59.8	27.7	18.7
Strict Low Middling	51.8	35.4	35.4
Low Middling	59.8	27.7	18.7
Unbleached			
Middling	66.1	26.1	34.6
Strict Low Middling	72.4	29.4	36.4
Middling	66.1	26.1	34.6
Low Middling	70.4	39.1	40.1
Strict Low Middling	72.4	29.4	36.4
Low Middling	70.4	39.1	40.1

SUMMARY U--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT GREEN 68)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White	60.4	27.1	25.4
Light Spot	61.3	24.0	13.3
White	60.4	27.1	25.4
Spot	61.6	36.3	33.2
White	60.4	27.1	25.4
Tinge	56.4	31.7	22.1
Light Spot	61.3	24.0	13.3
Spot	61.6	36.3	33.2
Light Spot	61.3	24.0	13.3
Tinge	56.4	31.7	22.1
Spot	61.6	36.3	33.2
Tinge	56.4	31.7	22.1
Unbleached			
White	64.0	1.6	64.0
Light Spot	61.8	0.4	61.7
White	64.0	1.6	64.0
Spot	58.7	6.2	58.7
White	64.0	1.6	64.0
Tinge	57.6	3.4	57.6
Light Spot	61.8	0.4	61.7
Spot	58.7	6.2	58.7
Light Spot	61.8	0.4	61.7
Tinge	57.6	3.4	57.6
Spot	58.7	6.2	58.7
Tinge	57.6	3.4	57.6

DIRECT OLIVE 70

Acceptance and Retention of Direct Olive 70 on the Basis of Grade of Cotton

Acceptance of Dye. As seen in Summary V, the acceptance of Direct Olive 70 by the bleached fabrics varied from 52.5 per cent for Low Middling cotton to 50.3 per cent for Middling cotton. In the greige state, Strict Low Middling cotton manifested the highest acceptance of Direct Olive 70 with a percentage of 56.1; while Middling cotton maintained the lowest acceptance, with an average of 53.4 per cent. Hence, it may be observed that there was little variation in acceptance of Direct Olive 70 dye on the basis of the class of cotton.

Fading during Light Exposure. Light fading produced results varying from a high color loss of 26.3 per cent in the bleached state for Low Middling cotton and 33.5 per cent for Strict Low Middling, to a low of 16.1 per cent for bleached Middling cotton and 31.8 per cent change for unbleached Low Middling cotton.

Fading during Laundering. Laundering caused a greater loss of color than did light fading in this instance, since the averages are generally lower; Low Middling cotton lost the most color (25.6 per cent) in bleached fabric as well as in unbleached fabric (36.1 per cent). Middling

cotton sustained the least color loss both for the bleached (21.2 per cent) and the unbleached (17.5 per cent) fabrics.

Acceptance and Retention of Direct Olive 70 on the Basis of Color of Cotton

Acceptance of Dye. The highest acceptance of color was made by bleached White cotton (58.4 per cent), although Spot cotton had the highest acceptance (50.8 per cent) for the unbleached cottons. Bleached Tinge cotton showed the lowest acceptance of this dye (47.4 per cent) as well as the lowest average (33.1 per cent) of acceptance by the unbleached Tinge cotton.

Fading during Light Exposure. The most color loss in light fading was observed in the bleached White (34.9 per cent), as well as in unbleached White cotton (45.7 per cent). The least color loss was found in the bleached Tinge cotton (20.5 per cent) and in the unbleached Tinge cotton (26.5 per cent).

Fading during Laundering. The laundering tests revealed somewhat less fading than did the light fading tests. White cotton lost more color both in the bleached state (30.5 per cent) and in the unbleached (34.3 per cent). Tinge cotton incurred the least color loss (17.4 per cent) for the bleached fabric and 18.5 per cent loss for the greige goods. In both the laundering and the light fading

tests, both in the bleached and unbleached state, White cotton lost the most color and Tinge cotton the least for the Direct Olive 70 dye.

SUMMARY V

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT OLIVE 70)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	50.3	16.1	21.2
Strict Low Middling	51.6	25.7	22.0
Middling	50.3	16.1	21.2
Low Middling	52.5	26.3	25.6
Strict Low Middling	51.6	25.7	22.0
Low Middling	52.5	26.3	25.6
Unbleached			
Middling	53.4	32.7	17.5
Strict Low Middling	56.1	33.4	28.3
Middling	53.4	32.7	17.5
Low Middling	54.6	31.8	36.1
Strict Low Middling	56.1	33.4	28.3
Low Middling	54.6	31.8	36.1

SUMMARY V--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT OLIVE 70)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White Light Spot	58.4 48.7	34.9 21.8	30.5 17.5
White Spot	58.4 55.8	34.9 28.6	30.5 28.2
White Tinge	58.4 47.4	34.9 20.5	30.5 17.4
Light Spot Spot	48.7 55.8	21.8 28.6	17.5 28.2
Light Spot Tinge	48.7 47.4	21.8 20.5	17.5 17.4
Spot Tinge	55.8 47.4	28.6 20.5	28.2 17.4
Unbleached			
White Light Spot	42.9 37.9	45.7 28.6	34.3 30.6
White Spot	42.9 50.8	45.7 30.8	34.3 26.8
White Tinge	42.9 33.1	45.7 26.5	34.3 18.6
Light Spot Spot	37.9 50.8	28.6 30.8	30.6 26.8
Light Spot Tinge	37.9 33.1	28.6 26.5	30.6 18.6
Spot Tinge	50.8 33.1	30.8 26.5	26.8 18.6

DIRECT BROWN 3

Acceptance and Retention of Direct Brown 3 on the Basis of Grade of Cotton

Acceptance of Dye. Data presented in Summary W are information concerning the acceptance and retention of Direct Brown 3. The highest acceptance of this dye was that shown by Middling cotton (60.4 per cent) when bleached goods were used, while Low Middling cotton demonstrated the lowest acceptance (59.1 per cent). Strict Low Middling cotton accepted the largest percentage of dye (63.0 per cent) in the unbleached fabrics, while Low Middling cotton accepted the smallest amount (62.6 per cent) in this state.

Fading during Light Exposure. Very low reflectance changes were observed for the light fading tests, since this brown dye did not reveal the true state of fading in these readings.

Here, the highest average reflectance for bleached fabric was 1.9 per cent for White cotton and 0.4 per cent for Strict Low Middling cotton. The unbleached fabrics maintained a slightly higher average of acceptance, ranging from 3.6 per cent for Low Middling cotton to 2.0 per cent for Strict Low Middling cotton. In both instances, Strict Low Middling showed a proclivity for the least fading as a result of exposure to light.

Fading during Laundering. Laundering produced a trend of higher readings than did light, thus indicating a positive loss of color. Low Middling cotton sustained the greatest color loss for this dye, with a 29.4 per cent change for the bleached and a 38.1 per cent change for the unbleached state. The least color loss for the fabric which was bleached before dyeing was in the Strict Low Middling cotton (21.0 per cent), with Middlingcotton showing the least loss (31.5 per cent) for the unbleached fabric.

Acceptance and Retention of Direct Brown 3 on the Basis of Color of Cotton

Acceptance of Dye. A definite trend was noted in comparing the color groups of cotton dyed with Direct Brown 3. White cotton showed the highest acceptance of this dye both in the bleached (63.1 per cent) and in the unbleached (66.1 per cent) fabrics; but Tinge cotton manifested the least color acceptance in the bleached state (56.4 per cent). White cotton showed the least acceptance in the unbleached state (61.0 per cent).

Fading during Light Exposure. More color loss due to light fading was noted in bleached White (1.9 per cent) as well as in the griege state of White cotton (5.8 per cent). The least color loss was found in the bleached Spot (-1.8 per cent) as well as in the unbleached Spot cotton (+1.2 per cent).

Fading during Laundering. Once more laundering contributed to a greater color loss for bleached White cotton (42.3 per cent) than did light fading. Spot cotton in the bleached and dyed state caused the least color loss. After laundering, the loss was 21.8 per cent in the bleached state; and in the unbleached state the loss was 25.4 per cent. Here, a disposition was seen for White cotton not only to accept a larger percentage of dye than did the other cottons, but also to lose the greater amount of dyes after laundering and light fading. In all but one instance, Spot cotton disclosed the lowest dye acceptance as well as the lowest color loss.

SUMMARY W

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT BROWN 3)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	60.4	1.9	25.6
Strict Low Middling	59.4	0.4	21.0
Middling	60.4	1.9	25.6
Low Middling	59.1	1.1	29.4
Strict Low Middling	59.4	0.4	21.0
Low Middling	59.1	1.1	29.4
Unbleached			
Middling	62.9	2.8	31.5
Strict Low Middling	63.0	2.0	36.8
Middling	62.9	2.8	31.5
Low Middling	62.6	3.6	38.2
Strict Low Middling	63.0	2.0	36.8
Low Middling	62.6	3.6	38.2

SUMMARY W--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT BROWN 3)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White	63.0	+1.9	29.8
Light Spot	60.4	-0.4	26.8
White	63.0	+1.9	29.8
Spot	58.0	-1.8	21.8
White	63.0	+1.9	29.8
Tinge	56.4	+0.5	23.6
Light Spot	60.4	-0.4	26.8
Spot	58.0	-1.8	21.8
Light Spot	60.4	-0.4	26.8
Tinge	56.4	+0.5	23.6
Spot	58.0	-1.8	21.8
Tinge	56.4	+0.5	23.6
Unbleached			
White	66.0	5.8	42.3
Light Spot	62.1	1.6	38.1
White	66.0	5.8	42.3
Spot	61.0	1.2	25.4
White	66.0	5.8	42.3
Tinge	61.6	4.6	41.8
Light Spot	62.1	1.6	38.1
Spot	61.0	1.2	25.4
Light Spot	62.1	1.6	38.1
Tinge	61.6	4.6	41.8
Spot	61.0	1.2	25.4
Tinge	61.6	4.6	41.8

DIRECT BLACK 91

Acceptance and Retention of Direct Black 91 on the Basis of Grade of Cotton

Acceptance of Dye. As observed from Summary X, bleached Middling cotton manifested the greatest acceptance of dye (79.4 per cent), while bleached Low Middling cotton showed a slightly lower acceptance (77.7 per cent). In the greige goods which were dyed, Strict Low Middling cotton showed the greatest acceptance (79.4 per cent) and Low Middling cotton exhibited the least acceptance (75.5 per cent), with the range between these two values very small.

Fading during Light Exposure. Fading due to light caused color loss to a lesser extent than during laundering, and the loss to the greatest extent occurred in Low Middling (23.0 per cent) in the bleached state and in Middling cotton (19.4 per cent) in the unbleached state. The smallest change of color was noted in the Middling grade of cotton (14.4 per cent) and in the Strict Low Middling grade (-9.8 per cent) in the unbleached cottons. The visual evaluations of Direct Black 91 dyed fabrics revealed extensive color loss, apparently the result of chemical changes in some components of the dye; however, spectrophotometric readings did not indicate an appreciable amount of color loss.

Fading during Laundering. Cottons subjected to the laundering test tended to produce high changes in the color of this dye. In the bleached fabrics, Middling cotton lost more color (58.3 per cent loss), while Low Middling lost the least amount (43.2 per cent). Strict Low Middling faded the most in the unbleached cottons (52.9 per cent), and Low Middling cotton lost the least color in the unbleached group.

Acceptance and Retention of Direct Black 91 on the Basis of Color of Cotton

Acceptance of Dye. Direct Black 91 dye was accepted best by White cotton both in the bleached (82.5 per cent) and in the unbleached cottons (80.0 per cent). The Tinge grade of cotton indicated the least dye acceptance both in the bleached (77.5 per cent) and in the unbleached (77.4 per cent) fabrics.

Fading during Light Exposure. Generally, the color losses from light fading ranged from Light Spot cotton for the highest change (21.8 per cent) to the bleached Tinge cotton for the lowest change (17.1 per cent). In the unbleached fabrics, White cotton ranked highest in color loss (21.8 per cent), while Light Spot cotton ranked lowest in color loss (15.4 per cent).

Fading during Laundering. Laundering manifested a definite tendency toward extreme fading for all cotton color classes, with a high loss of dye in the bleached Light Spot cotton (50.3 per cent) to the lowest loss of dye (42.1 per cent) in the bleached Tinge grade of cotton.

The unbleached fabrics revealed differences in the per cent of reflectance from 57.8 per cent for White cotton to 41.4 per cent for the Spotted grade of cotton.

SUMMARY X

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT BLACK 91)

PART I. GRADE OF COTTON

Grade	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
Middling	79.4	14.4	58.3
Strict Low Middling	79.0	20.7	56.4
Middling	79.4	14.4	58.3
Low Middling	77.7	23.0	43.2
Strict Low Middling	79.0	20.7	56.4
Low Middling	77.7	23.0	43.2
Unbleached			
Middling	79.4	19.4	45.3
Strict Low Middling	77.1	-9.8	52.9
Middling	79.4	19.4	45.3
Low Middling	76.5	14.1	45.5
Strict Low Middling	77.1	-9.8	52.9
Low Middling	76.5	14.1	45.5

SUMMARY X--Continued

COMPARISON OF THE PER CENT VARIATION IN REFLECTANCE BETWEEN UNDYED, DYED, AND DYED AND FADED FABRICS

(DIRECT BLACK 91)

PART II. COLOR OF COTTON

Color	Change Due to Dyeing	Change Due to Light Fading	Change Due to Laundering
Bleached			
White Light Spot	82.5 78.4	18.6 21.8	50.0 50.3
White Spot	82.5 76.3	18.6 20.2	50.0 48.1
White Tinge	82.5 77.5	18.6 17.1	50.0 42.1
Light Spot Spot	78.4 76.3	21.8 20.2	50.3 48.1
Light Spot Tinge	78.4 77.5	21.8 17.1	50.3 42.1
Spot Tinge	76.3 77.5	20.2 17.1	48.1 42.1
Unbleached			
White Light Spot	80.0 79.0	21.8 15.4	57.8 51.0
White Spot	80.0 77.2	21.8 17.1	57.8 41.4
White Tinge	80.0 74.4	21.8 8.8	57.8 44.6
Light Spot Spot	79.0 77.2	15.4 17.1	51.0 41.4
Light Spot Tinge	79.0 77.4	15.4 8.8	51.0 44.6
Spot Tinge	77.2 77.4	17.1 8.8	41.4 44.6

SUMMARY

The experimental fabrics used in this study were knitted from three grades and four color classes of Texas cotton. One group was dyed with 10 different hues of vat dyes, while the other was dyed with 10 different corresponding hues of direct dyes. In both groups, one-half of each fabric was bleached before dyeing and the remainder was dyed in the greige state.

These fabrics were subjected to 80 hours of light fading by means of the Fade-Ometer, and were given 25 launderings, using the Launder-Ometer. Light reflectances relative to the color change following dyeing, and to the exposure of the dyed fabrics to light and to laundering was measured by means of the Beckman Spectrophotometer.

The vat dyes generally were accepted to a greater degree by the grades and colors of cotton than were the direct dyes. Moreover, the vat dyes exhibited a greater degree of colorfastness to light and especially to laundering than did the direct dyes.

For the vat dyed fabrics, there were no significant differences in acceptance of the dyes by the three grades

of cotton.

Among the different colors of cotton, White surpassed Tinge in acceptance of the dyes in many comparisons of vat dyed fabrics with few differences between other initial colors of cotton.

For all grades and colors of cotton, light exposure caused only minor changes in vat dyed fabrics, whereas laundering caused varying degrees of fading in all of these dyed fabrics except Vat Black 9.

The fabrics which were bleached before the application of vat dyes did not differ markedly from the unbleached fabrics in acceptance of the dye, or in their response to light fading or to fading during laundering.

Some differences were noted between the acceptance of the direct dyes by the various grades and colors of experimental cotton. Irrespective of the treatment previous to the dyeing procedure the Middling and the Strict Low Middling grades and the White color of cotton were more susceptible to the dyes than were the remaining grade and colors.

The retention of the direct dyes through 80 hours of exposure to sunlight was most evident in the Strict Low

Middling grade, whereas after laundering the bleached Low Middling and the unbleached Middling were found to be superior in this respect. Spot cotton withstood both methods of fading in a more acceptable manner than that exhibited by White, Light Spot, and Tinge.

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A P P E N D I X

TABLE I

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS IN THE GREIGE STATE

Cotton Lot Number	Grade	Color	Mean Reflectance
1	Middling	White	69.2
2	Strict Low Middling	White	72.1
3	Low Middling	White	71.5
4	Middling	Light Spot	70.8
5	Strict Low Middling	Light Spot	64.4
6	Low Middling	Light Spot	68.9
7	Middling	Spot	66.7
8	Strict Low Middling	Spot	66.5
9	Low Middling	Spot	66.6
10	Middling	Tinge	63.8
11	Strict Low Middling	Tinge	63.7
12	Low Middling	Tinge	59.1

TABLE II

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT YELLOW AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	66.4	64.1	59.7	58.2	62.4	62.1
2	60.7	59.9	56.2	57.2	52.8	60.7
3	64.4	64.7	61.1	57.8	58.2	58.6
4	62.6	64.7	63.2	59.7	60.3	61.3
5	64.1	64.3	63.9	58.0	59.1	64.8
6	63.2	63.1	63.6	63.1	61.4	60.3
7	64.8	62.3	60.6	57.2	57.4	58.4
8	64.4	63.2	60.3	60.6	56.8	66.0
9	66.2	65.2	63.9	59.0	62.2	63.1
10	65.2	62.1	52.0	58.7	58.0	65.2
11	63.4	61.4	66.5	58.0	59.2	66.5
12	63.7	66.8	61.8	59.7	59.9	60.4

PART B. UNBLEACHED FABRIC

1	62.0	62.1	57.8	54.9	59.7	60.3
2	59.7	61.9	57.3	56.1	53.3	61.6
3	63.2	63.9	61.0	55.3	58.3	59.3
4	61.6	63.8	61.9	57.6	58.7	58.9
5	61.0	59.2	55.4	54.7	58.6	62.6
6	63.8	63.6	65.5	63.6	62.7	61.1
7	58.6	58.7	58.4	55.9	56.7	57.6
8	56.0	56.4	54.9	53.1	56.7	59.7
9	62.1	62.7	60.9	57.3	56.8	56.3
10	60.1	58.5	57.4	56.2	47.2	60.6
11	56.8	57.4	57.7	54.6	54.4	60.6
12	56.2	59.0	55.9	55.4	56.3	57.1

TABLE III

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT ORANGE 2 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	53.5	57.0	55.5	56.9	62.4	59.2
2	54.8	54.1	51.8	60.2	54.9	58.0
3	54.1	53.8	53.1	56.3	51.8	55.5
4	55.1	56.0	59.0	60.4	58.6	62.0
5	57.7	54.3	53.0	55.8	53.2	60.6
6	50.2	57.2	54.4	59.5	58.0	61.0
7	54.1	55.1	56.6	60.4	61.7	60.0
8	56.9	54.8	58.0	58.6	56.8	59.5
9	56.8	59.4	56.9	59.8	60.3	62.0
10	51.2	50.3	50.6	55.7	57.7	57.1
11	52.9	54.9	51.8	52.4	58.5	55.9
12	52.5	53.2	54.1	56.6	57.0	53.0

PART B. UNBLEACHED FABRIC

1	52.6	54.5	57.0	58.7	60.1	62.3
2	51.7	52.2	51.7	61.7	51.2	52.8
3	53.8	53.8	52.7	56.4	55.2	60.0
4	56.4	59.0	58.8	59.8	59.8	63.2
5	52.8	53.9	52.6	56.2	53.9	61.0
6	52.7	56.0	53.8	58.9	55.8	59.8
7	52.3	54.2	54.4	56.4	60.2	57.0
8	57.2	54.2	51.9	51.8	53.4	58.6
9	53.8	59.7	57.2	55.0	58.4	61.7
10	55.5	58.6	55.7	58.3	63.7	63.9
11	48.1	51.0	51.3	53.2	58.5	56.6
12	52.0	50.6	52.8	52.0	55.1	59.0

TABLE IV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT RED 10 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	48.2	51.7	51.9	53.0	54.1	51.8
2	50.0	49.4	47.8	51.4	48.9	49.4
3	53.2	53.7	54.4	47.4	50.4	51.9
4	51.2	53.1	52.8	56.8	52.0	55.0
5	52.6	51.4	53.5	52.6	51.8	52.0
6	53.6	53.2	55.0	54.6	54.7	50.4
7	51.7	52.4	52.1	52.1	52.9	53.6
8	49.6	50.2	52.7	52.0	49.1	50.6
9	54.1	55.4	55.7	55.4	52.2	55.8
10	55.3	47.7	53.2	51.9	51.3	50.6
11	52.6	50.2	52.6	51.9	48.1	49.1
12	51.1	52.3	53.3	51.8	50.7	52.7

PART B. UNBLEACHED FABRIC

1	46.7	53.2	51.7	50.4	51.1	50.0
2	49.0	48.8	47.3	51.2	49.7	49.2
3	44.9	50.2	53.0	49.5	51.9	53.7
4	54.2	52.7	49.9	46.9	49.6	51.8
5	49.8	46.5	52.6	52.9	46.1	51.7
6	46.9	50.7	51.7	53.2	50.9	50.9
7	50.6	49.4	47.9	52.2	51.0	51.1
8	47.8	49.4	50.3	51.0	50.8	51.0
9	48.9	52.3	51.9	52.8	51.7	51.3
10	50.2	44.9	50.0	52.2	49.5	54.6
11	47.2	46.1	47.6	47.6	44.3	46.6
12	44.7	47.3	48.3	50.7	47.3	47.8

TABLE V

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT VIOLET 13 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	46.1	46.6	44.7	46.6	48.2	48.2
2	41.1	41.5	43.0	42.1	42.0	42.6
3	44.9	44.8	43.8	44.6	45.6	46.6
4	46.5	46.2	46.8	47.2	48.1	47.4
5	45.6	43.2	46.4	45.3	45.3	40.0
6	44.6	44.1	43.4	41.7	44.9	45.6
7	45.3	46.3	48.7	45.5	46.6	47.1
8	43.3	44.5	43.7	44.0	44.6	42.7
9	49.1	45.8	43.9	44.2	46.3	48.8
10	44.4	45.0	48.7	42.2	44.1	48.4
11	44.8	45.8	41.8	45.3	46.3	46.7
12	45.9	46.8	47.3	43.9	48.0	48.7

PART B. UNBLEACHED FABRIC

1	46.4	48.6	49.9	44.9	45.7	46.1
2	41.9	41.4	40.6	40.6	43.3	44.1
3	43.8	43.6	44.5	39.6	45.4	45.7
4	42.3	46.3	46.1	45.6	45.2	45.8
5	41.6	42.4	43.0	42.5	42.7	41.7
6	42.9	45.6	46.0	43.6	45.6	45.1
7	44.6	45.2	45.6	43.4	47.3	47.5
8	43.9	42.1	42.1	42.7	43.2	43.0
9	44.0	44.8	43.2	43.2	43.1	47.0
10	48.3	41.8	43.8	42.1	44.3	46.1
11	40.8	43.3	42.7	42.4	45.9	44.8
12	42.8	42.9	40.8	45.2	45.2	47.3

TABLE VI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT BLUE 6 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	23.7	26.6	27.2	28.5	28.8	27.2
2	23.4	25.3	23.3	23.5	27.8	25.7
3	23.6	23.4	24.0	23.3	25.2	25.3
4	26.4	30.3	28.4	28.8	31.8	29.3
5	23.6	24.4	23.8	23.8	25.9	24.1
6	26.1	25.8	25.1	25.8	28.3	26.6
7	26.6	28.0	27.4	27.1	27.9	29.5
8	26.2	26.9	26.5	25.3	27.3	28.0
9	25.9	26.3	24.8	25.7	27.4	27.8
10	25.1	25.5	25.4	26.0	29.5	28.0
11	25.4	27.8	26.1	28.2	29.3	30.7
12	27.0	28.9	26.5	26.8	30.2	31.0

PART B. UNBLEACHED FABRIC

1	24.6	25.5	24.7	25.6	27.3	27.8
2	25.3	29.5	28.1	28.6	32.1	28.0
3	27.4	26.7	28.2	27.1	30.7	27.8
4	26.8	30.6	30.4	30.5	34.1	33.4
5	25.6	25.2	26.4	27.2	28.2	26.8
6	26.8	28.7	26.9	26.3	28.0	26.8
7	29.7	31.7	31.0	31.0	29.4	33.6
8	25.3	26.6	25.6	24.9	28.0	27.3
9	29.5	32.2	29.4	31.5	33.4	34.2
10	23.0	25.3	24.7	27.2	30.4	28.4
11	26.6	29.1	28.0	29.2	28.2	31.5
12	27.7	28.4	26.4	27.8	28.8	29.7

TABLE VII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT NAVY 18 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	23.9	24.4	23.4	24.4	26.3	26.2
2	26.8	25.7	26.0	26.1	27.3	29.5
3	25.5	26.0	23.5	23.7	26.4	26.8
4	24.9	22.6	21.9	23.3	25.8	25.5
5	24.7	24.4	24.2	25.4	24.9	26.0
6	24.3	25.3	25.7	23.6	25.1	25.6
7	27.3	25.4	26.4	26.4	28.1	28.5
8	24.9	25.8	26.2	26.5	26.7	27.7
9	25.2	24.4	24.7	25.6	25.1	25.8
10	25.5	24.2	26.0	24.8	26.2	27.7
11	24.7	23.7	24.3	22.8	25.2	25.3
12	24.5	24.2	25.4	25.7	25.5	26.1

PART B. UNBLEACHED FABRIC

1	25.1	23.7	24.1	25.7	26.9	26.5
2	22.9	22.9	25.5	24.6	29.2	28.9
3	26.3	26.3	26.0	24.3	26.5	27.5
4	23.7	22.6	23.5	23.7	25.0	26.2
5	25.0	25.7	23.7	25.1	25.0	26.4
6	23.8	24.8	24.1	25.4	25.8	27.2
7	27.3	26.0	24.8	26.5	27.2	28.3
8	23.3	22.6	23.5	22.7	24.5	24.4
9	24.9	24.5	24.1	24.0	25.6	26.4
10	26.7	25.7	26.7	26.2	26.3	27.5
11	23.1	21.6	23.2	21.3	23.3	24.8
12	23.4	21.2	22.2	22.8	21.8	23.2

TABLE VIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT GREEN 1 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	25.1	27.1	25.7	27.0	26.6	28.0
2	24.4	27.3	25.5	25.9	25.4	25.7
3	23.1	24.9	21.7	24.4	24.3	25.8
4	25.4	26.2	25.8	25.1	24.8	27.9
5	23.9	25.0	24.2	24.9	24.7	26.8
6	24.3	25.8	26.0	26.9	24.9	26.7
7	26.0	27.1	24.8	26.4	23.9	25.5
8.	24.7	26.6	24.1	25.8	25.1	26.6
9	26.4	28.6	28.3	29.7	28.9	31.1
10	29.3	28.8	27.8	27.0	28.3	31.7
11	25.9	26.7	25.6	27.0	25.4	28.0
12	26.0	29.1	28.0	28.0	28.7	30.1

PART B. UNBLEACHED FABRIC

1	25.1	27.4	25.5	26.2	27.6	26.8
2	24.6	26.0	23.2	23.7	24.9	25.9
3	24.6	22.3	23.4	24.3	24.5	26.0
4	26.4	25.9	25.4	27.0	28.3	27.5
5	24.0	23.5	24.3	24.7	25.4	27.8
6	25.0	27.8	25.4	27.4	26.0	28.6
7	26.6	25.6	24.8	27.0	27.0	27.9
8	26.4	27.8	25.9	27.5	26.9	28.5
9	26.0	26.0	26.0	27.0	26.3	29.4
10	28.8	26.5	25.5	27.8	27.5	32.2
11	23.5	25.8	25.6	25.2	25.4	26.7
12	25.0	24.2	24.7	25.8	23.4	27.0

TABLE IX

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT OLIVE 13 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	20.2	19.5	18.2	19.8	18.7	18.7
2	19.0	19.2	19.3	19.4	18.8	20.8
3	17.9	19.5	17.7	18.8	18.9	20.2
4	17.7	19.5	18.9	18.7	18.3	17.8
5	18.9	18.7	18.8	19.0	20.0	21.0
6	17.9	19.8	18.8	19.3	19.3	18.2
7	18.2	16.6	18.2	17.9	18.2	18.6
8	19.4	19.7	19.1	19.2	19.6	20.2
9	20.0	20.7	20.0	21.0	21.2	19.9
10	17.4	19.3	20.0	18.2	17.9	20.5
11	17.1	18.4	18.5	16.9	17.1	17.5
12	17.4	17.2	20.2	18.7	19.6	19.4

PART B. UNBLEACHED FABRIC

1	18.0	19.4	19.9	19.3	19.0	18.9
2	18.0	20.4	19.9	20.7	19.5	21.5
3	17.7	19.6	18.8	18.8	19.6	20.2
4	17.7	19.2	18.7	18.6	19.1	18.1
5	19.7	15.6	17.8	18.9	19.6	20.3
6	16.6	18.4	18.4	18.3	18.1	19.7
7	19.0	19.2	20.5	20.2	20.4	20.9
8	17.8	18.2	18.6	10.7	19.6	19.6
9	22.3	22.5	22.4	23.1	23.1	21.4
10	17.4	18.8	19.3	17.9	17.6	19.5
11	16.5	18.0	18.4	19.0	18.4	18.6
12	19.0	19.1	20.2	20.1	20.2	21.2

TABLE X

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT BROWN 1 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	38.8	39.1	38.3	39.8	43.8	42.1
2	37.9	35.9	35.1	39.9	41.4	42.0
3	41.8	41.4	42.1	41.5	45.3	45.6
4	39.6	39.1	38.7	39.4	44.6	41.9
5	38.7	39.3	38.5	39.7	40.6	42.5
6	40.4	39.9	40.1	42.1	44.3	43.7
7	38.8	38.0	37.4	38.6	42.0	42.7
8	33.4	33.2	32.4	36.0	37.1	37.7
9	40.3	40.4	39.9	41.1	42.1	43.2
10	40.2	40.9	40.3	40.9	41.8	43.5
11	40.8	39.8	40.4	40.8	41.1	43.1
12	41.9	41.5	41.9	41.9	44.2	46.5

PART B. UNBLEACHED FABRIC

1	39.9	37.3	36.9	39.2	41.4	43.0
2	35.7	37.2	35.0	40.7	41.3	42.4
3	39.7	38.8	38.9	43.1	43.5	44.2
4	40.7	39.4	39.6	40.9	42.8	42.9
5	37.0	37.9	37.1	38.1	40.5	40.5
6	38.2	38.4	37.8	38.3	42.2	39.6
7	39.5	38.3	39.1	40.6	41.7	41.7
8	35.2	35.1	35.2	36.3	38.6	42.0
9	40.5	40.2	39.3	40.0	42.9	42.8
10	39.8	41.0	41.6	42.6	43.5	44.1
11	39.4	39.4	39.6	41.1	40.2	40.5
12	41.9	44.4	43.3	43.8	45.1	44.4

TABLE XI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT BLACK 9 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	4.2	4.3	3.8	3.7	4.5	4.5
2	3.9	3.9	4.3	4.3	4.7	5.3
3	4.2	4.2	3.6	4.3	4.0	4.0
4	3.8	4.4	4.2	4.7	4.4	4.3
5	3.5	3.5	4.5	4.3	4.1	3.9
6	3.8	3.9	4.4	4.2	4.2	4.3
7	3.7	3.6	3.9	4.0	4.1	4.1
8	3.7	3.9	4.0	4.6	4.5	4.4
9	4.4	4.6	4.7	5.3	5.0	5.0
10	4.3	4.5	4.9	4.8	4.7	4.9
11	3.8	3.5	4.0	4.1	3.9	3.4
12	4.3	3.9	4.2	4.0	3.88	4.3

PART B. UNBLEACHED FABRIC

1	4.8	4.6	4.1	4.7	4.7	4.6
2	4.1	4.0	3.5	4.5	4.2	3.7
3	4.3	4.1	3.9	4.4	4.6	4.7
4	3.9	3.7	3.8	4.3	4.2	4.3
5	3.7	3.9	3.8	4.0	4.0	4.1
6	3.4	4.0	3.8	4.0	4.2	4.0
7	4.3	4.0	3.9	4.3	4.3	4.3
8	3.8	3.7	4.6	4.6	4.7	4.9
9	4.2	4.3	4.8	5.1	5.0	4.8
10	4.4	4.6	5.1	4.6	4.6	4.9
11	4.2	4.5	4.8	4.8	4.7	4.2
12	4.6	4.6	4.0	4.3	4.3	4.8

TABLE XII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT YELLOW 98 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	61.3	61.2	61.6	62.4	60.4	61.0
2	61.0	57.8	60.3	55.7	62.3	60.2
3	62.4	61.8	60.4	58.2	60.1	57.7
4	68.9	65.7	64.2	67.2	66.9	70.0
5	65.2	60.8	62.1	61.2	61.2	64.3
6	62.3	65.4	61.1	63.3	59.9	64.3
7	61.8	60.8	58.4	61.8	61.3	62.8
8	61.1	56.7	56.3	55.9	57.8	59.6
9	69.0	62.0	58.5	61.7	61.5	62.5
10	59.2	57.0	60.8	58.9	58.8	58.0
11	60.8	57.8	60.8	57.7	58.9	55.6
12	62.0	56.0	58.2	59.2	64.9	62.3

PART B. UNBLEACHED FABRIC

1	57.4	54.3	49.6	50.0	54.3	52.4
2	52.5	50.7	50.7	52.2	49.2	49.3
3	56.4	56.4	53.8	51.3	54.3	52.1
4	55.4	56.8	52.2	56.2	51.3	56.7
5	52.3	49.4	49.4	51.0	53.5	57.3
6	56.1	54.3	55.8	58.5	59.8	61.8
7	52.8	49.8	50.1	52.3	50.9	52.1
8	52.0	47.1	43.1	47.9	47.1	49.0
9	52.8	53.9	52.6	53.1	52.5	54.8
10	45.1	49.7	44.5	47.7	46.8	46.0
11	48.9	45.4	44.1	43.4	44.9	43.8
12	47.1	45.6	45.8	45.2	46.7	47.1

TABLE XIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT ORANGE 61 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	47.9	55.8	42.6	47.8	47.4	46.2
2	47.2	46.8	46.0	47.2	46.4	44.8
3	52.7	53.4	53.1	53.1	50.2	49.8
4	46.6	48.0	46.8	43.4	48.0	45.1
5	50.6	48.1	52.8	51.3	59.8	48.8
6	48.9	55.0	55.5	51.9	48.5	47.3
7	40.8	42.8	44.9	41.5	44.0	39.5
8	48.1	51.7	49.3	46.1	50.1	44.7
9	49.3	53.9	53.3	48.7	52.9	50.1
10	52.8	52.1	50.6	49.1	49.0	46.1
11	53.1	51.4	51.7	50.7	49.0	49.2
12	53.4	51.2	51.3	48.9	48.8	48.7

PART B. UNBLEACHED FABRIC

1	37.3	49.8	34.4	34.6	27.7	27.1
2	44.1	42.4	42.4	43.6	42.4	43.2
3	51.6	57.1	57.4	51.4	54.6	49.9
4	44.2	44.6	47.3	44.0	42.1	43.8
5	49.8	55.0	52.6	51.4	52.3	50.4
6	44.2	47.1	48.5	41.9	41.3	43.8
7	37.6	39.8	35.9	39.4	39.7	41.2
8	40.1	44.2	42.4	39.8	42.2	39.7
9	42.9	35.3	45.4	39.9	41.3	42.7
10	49.0	47.2	46.4	45.0	44.9	43.0
11	42.3	35.9	42.2	41.8	43.7	42.0
12	45.8	40.2	41.0	36.8	41.8	43.0

TABLE XIV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT RED 184 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	49.0	49.8	52.3	47.4	52.8	58.9
2	44.3	45.6	52.4	47.8	50.7	53.5
3	48.2	51.8	56.6	57.6	61.3	64.8
4	51.5	53.2	53.3	55.6	59.5	63.3
5	47.1	50.9	50.8	52.8	51.3	56.6
6	50.3	53.9	53.7	53.9	55.8	64.8
7	46.4	47.0	47.9	50.8	56.2	61.1
8	48.3	46.4	46.9	48.3	50.1	55.4
9	43.8	53.3	52.7	55.5	57.8	61.8
10	48.8	49.2	51.9	48.2	53.0	59.7
11	45.7	48.3	48.7	59.1	46.2	57.7
12	46.2	49.3	49.6	51.6	52.4	55.8

PART B. UNBLEACHED FABRIC

1	40.2	46.5	45.6	44.7	47.2	50.1
2	43.9	48.2	49.1	49.7	51.0	54.8
3	45.7	49.2	48.6	48.1	52.1	56.2
4	43.3	45.6	47.6	49.9	53.2	56.5
5	39.8	40.2	37.6	39.9	42.7	44.8
6	46.6	46.4	43.2	46.6	46.0	48.8
7	43.0	43.2	41.1	42.7	47.6	52.6
8	40.5	38.9	39.7	38.0	42.3	42.7
9	44.5	46.1	45.7	45.4	47.7	49.2
10	40.5	39.0	38.6	35.6	41.2	45.4
11	35.6	39.3	39.7	40.3	41.0	44.0
12	37.2	41.0	40.7	42.8	42.4	44.7

TABLE XV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT VIOLET 47 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	48.1	51.5	48.2	50.0	46.5	48.8
2	47.5	40.6	45.6	45.7	46.9	49.6
3	48.9	47.5	49.5	48.7	46.0	49.8
4	47.5	43.1	45.3	43.7	45.3	46.4
5	51.0	50.9	51.0	51.1	49.0	51.8
6	51.5	43.2	44.1	44.5	42.9	44.5
7	45.0	44.6	47.5	46.1	51.6	48.0
8	50.9	51.2	48.4	48.6	47.7	48.8
9	40.6	41.2	40.7	39.3	39.7	39.9
10	44.8	40.1	44.6	48.3	50.5	48.9
11	42.8	47.5	47.9	47.1	44.9	48.6
12	44.0	45.2	44.6	452.	46.4	47.0

PART B. UNBLEACHED FABRIC

1	44.2	44.4	45.3	44.5	42.3	43.6
2	42.8	44.5	42.6	43.4	42.7	42.3
3	44.2	45.3	46.3	44.7	47.6	45.8
4	45.6	44.8	44.5	44.9	45.7	43.9
5	41.3	39.8	37.5	38.7	40.1	38.4
6	51.5	48.7	50.6	48.3	49.8	48.2
7	50.9	47.8	48.6	49.1	45.2	48.6
8	40.3	38.9	38.3	39.4	39.7	39.4
9	42.3	41.2	41.0	40.2	39.1	40.8
10	37.3	48.0	36.7	39.9	38.3	42.4
11	34.3	37.0	38.8	38.6	37.3	39.0
12	34.2	36.3	36.9	37.6	38.3	39.0

TABLE XVI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT BLUE 14 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	20.7	21.5	22.7	26.7	28.5	33.3
2	20.8	22.5	20.6	24.1	25.6	26.9
3	21.7	23.1	23.6	28.8	27.3	31.7
4	21.8	24.5	25.4	29.1	30.5	34.3
5	23.0	22.3	23.7	24.4	25.4	26.6
6	23.8	23.2	26.3	29.8	30.1	29.4
7	19.7	23.2	24.4	27.8	29.5	29.3
8	23.8	20.8	25.7	25.8	28.9	30.1
9	23.5	22.8	23.1	26.3	29.7	30.7
10	19.1	21.6	24.0	24.8	27.6	30.2
11	23.4	23.1	26.3	28.0	29.0	33.0
12	23.9	25.2	24.5	25.2	31.6	33.6

PART B. UNBLEACHED FABRIC

1	19.8	20.7	19.4	22.9	23.4	25.6
2	21.7	23.2	24.1	24.6	26.7	30.6
3	21.7	21.3	23.5	25.5	26,0	28.2
4	24.1	23.0	24.8	28.1	29.5	31.1
5	22.7	22.2	23.0	24.4	26.1	28.0
6	21.8	21.3	24.8	26.2	28.5	32.7
7	21.1	21.0	23.7	24.4	25.6	30.6
8	20.8	22.1	23.7	25.1	24.7	26.5
9	23.6	21.7	25.5	22.1	25.5	26.5
10	22.0	22.3	24.0	25.0	26.6	29.7
11	23.6	23.7	24.9	28.0	26.7	28.5
12	20.3	22.9	24.9	26.4	28.6	30.6

TABLE XVII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT NAVY 252 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	13.8	12.5	12.7	13.3	12.6	13.4
2	13.0	12.9	12.1	12.9	13.3	15.1
3	15.3	14.5	14.4	14.2	12.1	14.6
4	13.0	13.3	11.9	13.0	12.1	14.3
5	13.2	13.1	12.3	12.0	12.8	12.8
6	13.9	13.1	13.8	13.8	12.9	13.4
7	12.7	12.1	11.5	11.8	11.1	12.6
8	12.4	11.4	10.5	12.2	10.5	10.6
9	16.0	14.5	13.5	14.4	14.7	15.7
10	11.9	12.1	11.1	11.3	11.1	11.1
11	13.6	13.5	12.0	12.6	12.6	13.6
12	13.9	14.5	13.6	14.0	13.8	14.0

PART B. UNBLEACHED FABRIC

1	12.7	13.3	12.2	13.4	14.1	13.1
2	14.6	13.6	11.7	13.1	13.8	12.6
3	13.5	13.6	14.1	13.2	12.6	13.6
4	14.0	13.6	13.4	13.4	12.6	15.0
5	12.0	12.8	13.0	12.4	13.0	13.3
6	12.5	11.8	11.4	14.6	12.5	14.2
7	13.5	13.3	13.0	12.6	11.9	13.1
8	13.2	10.7	11.0	10.8	12.5	14.5
9	15.9	13.7	12.3	14.2	13.5	15.1
10	12.3	13.5	12.7	15.1	13.5	15.6
11	11.6	12.5	11.2	12.7	12.3	14.4
12	13.1	13.4	13.6	12.6	13.4	14.6

TABLE XVIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT GREEN 68 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	24.9	23.1	26.9	30.6	33.1	35.9
2	28.7	29.7	32.2	37.6	38.3	44.7
3	30.6	32.5	35.1	37.6	44.2	54.3
4	29.8	28.1	28.6	39.3	41.1	46.1
5	26.9	28.2	30.0	34.4	39.3	44.8
6	22.1	21.1	21.1	27.3	28.4	32.3
7	23.1	24.3	29.0	27.9	35.9	40.8
8	24.5	26.6	27.9	33.6	38.9	44.4
9	29.1	28.9	34.5	40.8	43.4	46.7
10	29.2	26.5	32.3	38.3	44.3	45.9
11	27.2	27.8	34.8	39.2	44.0	48.9
12	24.8	24.1	26.7	26.9	32.8	42.3

PART B. UNBLEACHED FABRIC

1	20.4	20.9	22.6	29.7	30.1	33.2
2	16.3	17.6	18.5	22.0	24.8	25.5
3	20.2	22.5	24.6	28.6	30.4	36.8
4	28.5	27.5	29.8	36.4	42.3	47.3
5	15.6	15.2	16.4	19.6	20.6	23.7
6	16.4	18.5	19.3	21.6	24.7	27.9
7	21.1	22.4	24.3	35.3	32.8	36.2
8	21.0	21.4	23.6	29.4	31.0	34.6
9	21.5	22.5	24.4	28.3	32.9	39.3
10	22.4	20.3	23.7	25.6	30.6	32.8
11	20.6	19.9	23.7	25.3	28.6	34.4
12	20.5	21.9	24.2	29.5	33.1	35.9

TABLE XIX

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT OLIVE 70 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	28.3	32.3	41.7	47.7	49.5	51.1
2	29.6	30.8	31.5	40.1	41.0	42.3
3	30.7	32.4	31.6	37.2	42.9	44.4
4	29.9	31.8	30.9	36.3	42.6	45.1
5	38.0	35.1	39.7	41.4	45.3	47.4
6	36.8	38.0	40.8	47.7	55.3	59.8
7	30.4	32.5	32.3	36.0	41.9	45.1
8	25.8	30.1	32.4	38.2	41.6	42.0
9	32.1	32.7	35.5	40.1	40.8	44.8
10	35.8	31.1	33.4	33.5	41.8	43.4
11	35.8	35.5	39.9	45.3	54.5	57.7
12	26.6	28.4	32.1	35.8	38.8	40.3

PART B. UNBLEACHED FABRIC

1	29.3	32.8	42.5	51.2	52.2	53.4
2	27.2	34.2	32.1	34.9	44.9	45.9
3	27.6	28.1	31.8	36.8	45.0	46.1
4	32.4	34.6	35.3	37.8	45.1	50.3
5	29.2	29.0	32.2	37.0	40.5	40.9
6	28.8	24.1	34.5	40.0	49.0	50.7
7	34.3	30.5	33.7	38.7	44.2	45.7
8	31.9	33.9	37.0	40.0	47.9	53.4
9	35.4	38.6	43.8	49.4	50.6	56.2
10	29.5	33.6	37.2	37.2	48.3	50.3
11	28.8	29.7	30.7	35.5	38.8	41.0
12	29.1	28.4	30.9	34.8	36.2	39.6

TABLE XX

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT BROWN 3 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	26.4	24.3	24.8	24.7	25.7	27.0
2	27.2	26.2	26.4	25.1	27.2	28.1
3	24.9	26.0	25.1	25.2	26.3	28.9
4	24.4	22.7	25.0	25.1	25.6	27.1
5	27.3	25.0	25.2	26.5	28.8	28.7
6	29.0	28.9	26.8	28.4	30.0	29.1
7	28.2	25.8	26.8	27.1	29.4	27.9
8	28.4	26.7	25.0	26.3	28.4	29.0
9	27.3	28.2	26.1	27.3	28.7	29.5
10	28.4	27.8	24.5	27.5	28.9	28.6
11	25.4	28.0	25.8	25.6	28.1	29.1
12	27.5	26.0	24.4	26.0	29.1	29.0

PART B. BLEACHED FABRIC

1	23.8	24.5	24.8	20.3	26.5	28.0
2	26.7	24.9	25.1	25.0	27.8	27.0
3	21.7	25.0	26.3	24.9	26.0	26.9
4	26.0	25.5	26.9	26.6	28.9	28.3
5	24.4	23.9	24.2	21.2	26.3	26.0
6	26.8	26.2	24.2	26.7	26.4	27.1
7	26.9	25.9	26.0	25.8	27.5	26.9
8	24.4	23.9	23.2	23.6	25.4	26.2
9	26.6	27.0	24.5	25.7	27.0	26.8
10	23.7	24.1	23.5	26.1	24.7	26.5
11	23.4	22.7	25.4	24.7	25.7	26.7
12	24.5	23.6	22.1	25.0	26.8	27.3

TABLE XXI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT BLACK 91 AFTER A SPECIFIED NUMBER OF HOURS OF EXPOSURE IN THE ATLAS FADE-OMETER

PART A. BLEACHED FABRIC

Cotton Lot Number	HOURS OF EXPOSURE IN FADE-OMETER					
	0	5	20	40	60	80
1	13.0	12.7	14.6	14.5	15.2	16.2
2	11.9	10.6	11.9	15.0	14.9	16.1
3	12.2	12.8	14.5	17.5	16.5	17.2
4	13.7	13.9	14.6	15.1	16.3	16.5
5	14.6	16.8	18.1	20.1	19.9	21.1
6	15.7	15.4	17.5	19.7	21.9	21.8
7	16.0	16.7	18.8	18.2	19.4	21.3
8	16.4	16.2	18.2	18.0	20.9	21.6
9	15.1	16.8	18.4	18.5	20.4	21.5
10	12.6	13.2	14.9	14.0	16.9	15.0
11	13.2	14.2	15.2	16.4	17.3	15.8
12	16.3	16.8	17.9	19.6	20.0	18.8

PART B. UNBLEACHED FABRIC

1	14.1	16.5	17.4	18.0	18.9	19.7
2	12.5	12.4	13.0	14.6	14.8	15.9
3	16.1	16.9	19.1	18.9	21.2	22.4
4	13.1	13.9	14.6	15.4	16.1	17.2
5	15.0	15.6	16.2	17.3	19.6	19.8
6	14.8	14.7	15.7	15.9	17.1	18.4
7	14.3	15.1	16.5	18.6	18.8	19.2
8	15.9	16.6	17.3	19.2	20.1	20.8
9	15.5	15.7	16.8	17.1	18.1	17.4
10	14.1	13.1	14.0	15.3	17.5	16.3
11	17.6	15.0	18.9	19.7	19.7	20.2
12	16.1	16.1	17.8	19.9	17.6	19.1

TABLE XXII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT YELLOW AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	66.4	67.3	72.4	74.8	81.7	79.4
2	60.7	66.0	67.4	67.3	72.7	68.8
3	64.4	69.8	71.9	77.3	75.6	75.5
4	62.6	71.6	69.0	72.1	73.2	74.1
5	64.1	65.2	57.2	74.9	73.6	70.3
6	63.2	65.4	72.3	70.0	72.4	73.2
7	64.8	65.4	70.0	74.2	76.3	71.8
8	64.4	69.2	74.5	73.9	72.3	69.8
9	66.2	66.0	73.1	79.3	79.3	78.0
10	65.2	67.7	71.4	75.6	80.7	82.4
11	63.4	67.1	72.9	78.2	78.9	81.3
12	63.7	61.0	72.3	75.2	78.0	81.0

PART B. UNBLEACHED FABRIC

1	62.0	63.2	73.3	72.6	75.6	77.0
2	59.7	62.0	71.7	71.5	76.9	72.0
3	63.2	67.3	76.2	74.9	77.7	77.0
4	61.6	66.6	68.5	70.9	71.2	74.4
5	61.0	64.5	67.9	72.1	69.8	71.6
6	63.8	66.7	68.9	68.8	73.5	71.8
7	58.6	63.3	69.5	68.5	70.1	70.1
8	56.0	64.0	62.5	65.4	66.4	63.7
9	62.1	66.9	74.1	73.5	74.9	72.5
10	60.1	63.7	72.1	69.0	72.1	76.6
11	56.8	60.6	64.1	69.0	78.0	78.0
12	56.2	59.1	72.6	68.2	68.6	70.9

TABLE XXIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT ORANGE 2 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	53.5	60.8	63.5	59.3	66.0	67.6
2	54.8	59.2	57.5	58.0	58.9	58.9
3	54.1	57.2	59.9	62.0	61.0	59.4
4	55.1	63.7	66.2	63.7	60.5	67.3
5	57.7	63.7	63.8	68.0	64.1	65.7
6	50.2	61.8	58.4	62.3	63.8	64.0
7	54.1	60.6	65.4	64.6	66.7	67.9
8	56.9	57.3	59.8	63.3	64.5	67.4
9	56.8	60.2	64.3	59.3	66.2	67.3
10	51.2	60.8	58.7	59.6	61.3	60.8
11	52.9	62.0	54.6	61.3	65.2	64.1
12	52.5	60.9	62.4	63.6	60.3	60.4

PART B. UNBLEACHED FABRIC

1	52.6	63.8	60.4	63.2	68.0	67.7
2	51.7	55.1	57.1	63.0	62.1	60.5
3	53.8	59.6	58.7	62.9	62.5	64.5
4	56.4	61.5	62.6	64.7	65.5	68.1
5	52.8	60.0	63.9	63.2	65.1	65.7
6	52.7	61.3	65.5	85.0	65.4	66.5
7	52.3	59.1	60.7	63.4	62.0	64.4
8	57.2	62.8	65.6	63.8	64.8	66.6
9	53.8	62.1	61.1	59.1	64.6	66.7
10	55.5	62.0	59.3	59.4	65.9	65.4
11	48.1	60.1	57.5	56.7	59.6	61.6
12	52.0	57.9	63.1	59.5	62.2	64.3

TABLE XXIV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT RED 10 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	48.2	61.7	60.7	60.0	63.9	62.8
2	50.0	57.1	57.8	56.9	60.3	61.7
3	53.2	53.7	58.7	58.7	62.0	62.2
4	51.2	60.0	58.7	58.7	57.5	57.2
5	52.6	53.6	57.6	59.0	62.2	61.9
6	53.6	62.0	58.5	61.8	62.8	67.4
7	51.7	59.5	56.6	60.2	60.3	60.4
8	49.6	58.5	59.7	54.5	57.3	57.5
9	54.1	60.6	60.2	61.4	62.2	62.4
10	55.3	59.3	56.4	60.4	63.5	65.8
11	52.6	59.3	57.2	59.5	56.6	59.4
12	51.1	57.5	60.1	59.8	65.2	62.0

PART B. UNBLEACHED FABRIC

1	46.7	59.1	58.0	58.8	53.4	58.4
2	49.0	53.6	57.0	56.6	61.0	63.2
3	44.9	55.4	57.9	57.6	58.1	62.1
4	54.2	61.1	60.1	60.8	59.1	61.0
5	49.8	58.4	56.7	59.3	61.5	62.4
6	46.9	59.3	58.6	58.4	58.2	61.3
7	50.6	61.0	58.2	60.8	62.1	60.5
8	47.8	56.7	54.5	52.5	53.2	64.2
9	48.9	57.8	58.7	58.8	59.1	61.8
10	50.2	55.3	57.4	56.9	58.1	58.7
11	47.2	56.9	58.2	56.8	55.6	54.3
12	44.7	58.4	57.9	56.5	57.3	62.7

TABLE XXV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT VIOLET 13 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	46.1	51.7	50.8	49.5	55.5	54.3
2	41.1	47.4	47.9	45.0	46.6	50.6
3	44.9	50.5	59.8	44.8	52.9	52.7
4	46.5	53.1	51.3	52.4	49.3	55.4
5	45.6	52.0	51.5	46.4	50.5	52.0
6	44.6	53.9	49.8	50.4	45.2	53.6
7	45.3	52.5	52.3	47.4	47.6	52.2
8	43.6	53.3	53.6	55.1	46.9	49.8
9	49.1	51.7	55.6	46.4	57.5	57.7
10	44.4	54.2	54.0	55.7	54.0	57.0
11	44.8	50.8	53.5	51.9	50.0	53.4
12	45.9	54.6	53.7	53.9	52.4	52.5

PART B. UNBLEACHED FABRIC

1	46.4	53.0	54.1	48.4	53.8	54.8
2	41.9	48.0	50.7	45.0	51.3	52.6
3	43.8	49.6	50.2	47.8	54.4	56.8
4	42.3	52.1	51.4	52.0	49.2	51.3
5	41.6	51.4	51.0	46.2	51.8	49.6
6	42.9	48.8	48.8	51.2	47.9	51.9
7	44.6	51.3	51.9	50.5	47.1	52.3
8	43.9	50.1	52.2	48.4	45.9	52.1
9	44.0	51.5	52.1	49.0	53.9	57.6
10	48.3	54.5	52.0	54.8	56.1	57.3
11	40.8	52.8	51.8	51.5	50.5	53.9
12	42.8	48.6	52.5	46.3	48.4	46.7

TABLE XXVI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT BLUE 6 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	23.7	30.5	29.3	33.2	32.7	32.5
2	23.4	28.6	27.2	31.2	31.4	32.1
3	23.6	26.8	29.3	29.2	33.0	30.6
4	26.4	35.4	38.4	37.2	36.3	36.8
5	23.6	30.6	26.8	29.3	32.3	27.4
6	26.1	31.6	30.8	34.0	34.3	32.7
7	22.6	31.8	33.8	32.4	33.9	33.4
8	26.2	31.9	29.4	31.8	31.8	33.0
9	25.9	32.4	32.7	37.0	36.0	35.2
10	25.1	33.6	32.9	34.8	33.2	35.8
11	25.4	33.6	33.6	35.8	35.6	34.4
12	27.0	34.5	31.3	36.1	33.6	35.0

PART B. UNBLEACHED FABRIC

1	24.6	30.9	30.4	33.1	33.7	34.4
2	25.3	34.1	31.1	36.6	36.1	36.8
3	27.4	30.0	34.7	34.6	37.4	35.4
4	26.8	37.0	36.2	38.7	37.5	38.1
5	25.6	32.2	32.7	34.4	35.1	34.1
6	26.8	33.1	30.7	35.1	35.2	33.6
7	29.7	36.3	38.6	34.3	41.1	40.6
8	25.3	32.6	30.4	32.6	32.7	33.4
9	29.5	39.0	38.0	41.6	42.3	41.8
10	23.0	32.7	28.3	34.5	32.1	30.9
11	26.6	35.8	32.3	35.1	34.1	35.4
12	27.7	34.7	32.9	35.7	34.3	33.5

TABLE XXVII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT NAVY 18 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	23.9	26.7	29.2	29.5	30.2	32.0
2	26.8	30.3	28.8	31.8	33.4	32.0
3	25.5	27.9	28.0	29.9	31.0	29.3
4	24.9	27.4	28.2	30.7	30.8	29.1
5	24.7	30.1	30.0	31.1	30.3	30.5
6	24.3	30.4	29.8	30.9	29.8	31.2
7	27.3	28.3	29.7	32.5	33.8	32.9
8	24.9	30.1	31.5	29.8	28.3	30.3
9	25.2	29.5	30.3	30.8	30.5	33.7
10	25.5	28.8	27.4	30.2	30.9	30.6
11	24.7	28.8	28.7	29.5	30.0	30.3
12	24.5	30.5	29.5	28.8	30.1	28.2

PART B. UNBLEACHED FABRIC

1	25.1	30.4	30.2	32.2	28.9	32.4
2	22.9	30.1	28.0	29.2	30.4	29.9
3	26.3	29.0	33.6	35.3	33.3	30.6
4	23.7	28.0	26.4	31.1	29.3	30.1
5	25.0	31.7	31.8	32.2	33.0	34.1
6	23.8	28.2	30.6	30.3	32.9	29.3
7	27.3	32.8	30.1	34.6	34.7	33.2
8	23.3	29.8	31.3	31.1	29.4	31.2
9	24.9	27.3	30.7	30.1	32.2	32.0
10	26.7	28.9	29.7	31.2	32.2	30.9
11	23.1	27.7	29.7	30.8	31.9	30.8
12	23.4	28.9	30.3	29.9	27.2	31.8

TABLE XXVIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT GREEN 1 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	25.1	29.0	26.9	29.6	30.4	34.2
2	24.4	28.0	31.9	34.7	34.4	33.2
3	23.1	27.5	31.2	30.7	31.4	31.4
4	25.4	28.8	29.0	31.7	31.8	34.2
5	23.9	28.8	29.3	31.4	32.9	33.4
6	24.3	30.6	31.4	33.3	34.2	33.0
7	26.0	28.3	33.1	32.4	34.2	35.3
8	24.7	31.0	32.6	35.0	34.9	34.6
9	26.4	31.3	38.2	33.6	35.1	35.6
10	29.3	29.5	33.2	33.5	33.0	34.7
11	25.9	27.8	29.8	30.5	35.4	35.6
12	26.0	27.5	29.7	29.4	32.3	34.6

PART B. UNBLEACHED FABRIC

1	25.1	28.9	29.0	30.7	32.4	35.1
2	24.6	28.5	28.8	32.9	32.6	33.7
3	24.6	29.1	32.8	32.5	33.0	33.1
4	26.4	30.0	33.3	35.8	36.6	34.7
5	24.0	28.2	22.5	27.5	31.9	33.1
6	25.0	31.7	33.9	35.6	33.2	35.6
7	26.6	28.5	32.8	32.1	35.9	35.0
8	26.4	32.1	34.8	35.2	34.6	36.2
9	26.0	31.8	35.9	33.3	35.2	35.2
10	28.8	28.7	35.2	33.2	36.3	34.8
11	23.5	25.2	31.8	31.6	32.0	32.5
12	25.0	25.4	27.7	27.8	32.8	33.1

TABLE XXIX

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT OLIVE 13 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	20.2	22.8	23.6	27.7	29.2	26.4
2	19.0	23.2	26.3	26.2	28.1	26.3
3	17.9	23.1	23.9	26.4	27.4	26.3
4	17.7	20.9	23.2	25.9	26.2	24.3
5	18.9	24.8	24.9	26.4	25.9	24.1
6	17.9	22.3	25.3	24.7	25.1	26.6
7	18.2	21.3	23.3	25.2	27.8	26.2
8	19.4	19.9	24.1	24.3	25.7	24.1
9	20.0	26.0	27.6	29.8	30.2	29.1
10	17.4	21.3	22.8	24.5	22.7	25.3
11	17.1	21.2	23.8	26.9	25.4	25.8
12	17.4	22.2	23.9	24.1	24.6	28.4

PART B. UNBLEACHED FABRIC

1	18.0	23.9	26.6	27.8	27.8	27.5
2	18.0	23.3	26.8	29.1	28.9	26.6
3	17.7	21.0	23.0	25.6	25.7	25.1
4	17.7	21.8	23.6	25.3	28.1	26.5
5	19.7	22.3	25.3	26.0	28.4	26.6
6	16.6	20.4	23.2	24.2	26.4	24.8
7	19.0	24.6	26.7	24.9	28.8	28.7
8	17.8	23.9	26.6	24.6	27.3	27.3
9	22.3	22.1	25.8	24.6	27.4	25.7
10	17.4	20.6	22.7	25.7	26.3	26.4
11	16.5	21.3	24.5	25.3	25.1	25.9
12	19.0	23.2	24.1	29.5	28.5	27.2

TABLE XXX

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT BROWN 1 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	38.8	39.6	43.3	44.1	44.6	44.3
2	37.9	40.2	40.9	45.8	43.8	46.6
3	41.8	48.8	48.4	49.8	47.5	50.9
4	39.6	48.3	44.6	44.5	45.7	47.8
5	38.7	42.4	44.3	43.1	46.1	45.6
6	40.4	44.8	43.2	47.0	46.7	48.8
7	38.8	41.3	42.2	47.4	47.3	48.8
8	33.4	40.2	39.0	39.3	40.7	42.7
9	40.3	43.9	41.3	42.4	47.9	45.6
10	40.2	45.3	45.6	44.7	48.1	47.3
11	40.8	46.0	44.3	45.8	46.3	51.6
12	41.9	49.4	47.1	50.7	46.8	50.0

PART B. UNBLEACHED FABRIC

1	38.9	42.2	43.1	45.1	44.4	45.0
2	35.7	41.2	40.2	48.1	46.2	41.9
3	39.7	44.2	45.0	48.6	46.9	47.8
4	40.7	46.6	46.7	47.3	49.6	48.5
5	37.0	40.7	40.3	40.7	47.2	45.5
6	38.2	41.3	42.3	42.2	45.0	45.5
7	39.5	43.1	42.3	48.2	50.2	47.7
8	35.2	37.0	37.3	38.4	38.5	41.7
9	40.5	43.3	41.5	40.6	46.6	46.2
10	39.8	45.6	44.4	46.5	47.9	44.9
11	39.4	42.4	41.4	46.7	46.7	48.5
12	41.9	46.6	45.9	50.8	49.5	48.0

TABLE XXXI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH VAT BLACK 9 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	4.2	4.5	3.9	4.0	4.3	4.1
2	3.9	4.5	4.2	4.3	4.5	4.0
3	4.2	3.9	4.2	4.1	4.5	4.2
4	3.8	4.1	4.0	4.6	4.5	4.4
5	3.5	3.8	3.8	3.6	4.1	4.0
6	3.8	4.0	4.2	4.4	4.5	4.3
7	3.7	3.9	3.7	3.8	4.3	4.0
8	3.7	3.6	4.7	4.0	4.3	4.8
9	4.4	4.7	4.6	4.3	4.6	4.3
10	4.3	3.8	4.9	4.5	5.0	4.7
11	3.8	4.5	4.0	4.0	3.7	4.1
12	4.3	4.6	4.7	4.4	4.0	4.0

PART B. UNBLEACHED FABRIC

1	4.8	5.6	4.1	5.0	4.9	4.9
2	4.1	4.9	3.8	4.0	4.4	4.3
3	4.3	5.1	4.0	4.1	4.5	4.4
4	3.7	4.1	4.6	4.0	4.5	3.8
5	3.7	3.8	4.2	4.7	4.0	4.0
6	3.4	3.4	3.6	4.0	4.1	3.9
7	4.3	4.3	4.3	5.1	4.5	4.4
8	3.8	4.1	4.2	4.3	4.2	4.4
9	4.2	4.6	5.0	4.6	4.4	4.4
10	4.4	5.0	4.2	5.0	4.7	5.4
11	4.2	4.3	4.2	4.2	4.6	4.4
12	4.6	5.4	5.1	5.3	5.4	5.4

TABLE XXXII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT YELLOW 98 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	61.3	80.8	79.6	84.6	88.3	89.7
2	61.0	73.6	79.4	79.5	82.4	82.8
3	62.4	65.9	69.0	81.8	85.8	87.7
4	68.9	75.5	88.5	88.6	94.2	92.3
5	65.2	72.5	74.0	78.6	82.6	85.3
6	62.3	72.3	80.1	85.2	87.1	93.4
7	61.8	72.8	79.9	85.4	84.1	91.6
8	61.1	71.7	74.9	82.0	82.2	83.2
9	69.0	72.1	73.9	88.3	89.8	91.8
10	59.2	73.5	74.2	72.2	80.7	86.8
11	60.8	72.7	71.7	76.4	79.8	81.6
12	62.0	74.5	70.4	80.7	84.3	79.0

PART B. UNBLEACHED FABRIC

1	57.4	59.8	67.7	81.7	76.5	80.1
2	52.5	68.3	66.9	71.3	77.9	79.0
3	56.4	62.5	67.8	64.2	74.0	82.2
4	55.4	61.2	70.3	70.4	80.1	86.6
5	52.3	60.6	64.0	73.9	78.2	81.9
6	56.1	62.6	70.4	68.3	74.6	83.1
7	52.8	62.2	65.9	69.1	83.4	84.8
8	52.0	56.7	59.0	65.7	73.2	78.7
9	52.8	60.5	65.5	76.8	82.5	87.3
10	45.1	57.4	56.3	69.2	71.7	69.6
11	48.9	57.8	56.7	63.9	69.1	72.2
12	47.1	59.2	65.0	67.9	72.7	72.5

TABLE XXXIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT ORANGE 61 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	47.9	61.9	68.9	77.7	79.0	80.8
2	47.2	57.5	65.7	71.2	77.7	79.2
3	52.7	67.3	68.4	76.3	77.1	78.8
4	46.6	62.7	63.2	70.4	83.0	76.6
5	50.6	65.8	76.6	72.3	83.9	84.8
6	48.9	66.7	69.3	75.4	81.6	83.2
7	40.8	54.0	58.9	67.6	68.1	71.2
8	48.1	66.2	62.3	70.9	72.8	79.6
9	49.3	67.4	73.5	78.1	80.1	82.7
10	52.8	61.0	67.8	77.9	78.2	80.2
11	53.1	66.8	71.0	62.7	69.9	73.6
12	53.4	68.1	65.3	78.5	78.2	80.4

PART B. UNBLEACHED FABRIC

1	37.3	63.4	73.8	78.8	78.2	80.6
2	44.1	54.5	62.3	67.8	70.3	73.9
3	51.6	68.5	73.2	78 5	78.6	80.6
4	44.2	62.2	66.2	67.5	71.5	77.9
5	49.8	63.9	68.2	69.0	83.3	84.7
6	44.2	60.8	65.8	74.8	78.5	80.6
7	37.6	50.1	57.8	54.1	71.4	74.5
8	40.1	51.3	58.2	64.3	69.3	72.2
9	42.9	53.9	62.2	63.0	76.8	78.6
10	49.0	61.5	67.4	72.9	73.5	75.8
11	42.3	55.4	58.3	67.8	71.4	76.3
12	45.8	58.2	61.4	72.7	67.6	74.6

TABLE XXXIV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT RED 184 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	49.0	56.5	58.8	56.9	58.6	56.8
2	44.3	48.8	51.3	54.4	54.5	55.5
3	48.2	53.3	57.8	55.5	57.3	57.7
4	51.5	54.7	63.6	57.2	59.0	66.0
5	47.1	52.6	56.2	55.5	54.8	54.8
6	50.3	54.3	55.2	56.6	58.2	60.3
7	46.4	49.2	49.4	51.0	53.5	59.1
8	48.3	50.3	53.0	56.6	60.4	59.7
9	43.8	56.4	62.2	57.1	57.0	65.6
10	48.8	53.4	55.7	57.8	56.9	57.3
11	45.7	52.2	53.1	57.2	56.3	58.1
12	46.2	52.5	51.1	55.0	56.6	55.8

PART B. UNBLEACHED FABRIC

1	40.2	48.1	51.9	51.7	54.5	53.8
2	43.9	44.8	50.8	52.0	51.9	51.7
3	45.7	49.2	52.4	52.9	55.2	57.8
4	43.3	47.7	52.8	52.4	54.2	61.4
5	39.8	53.2	47.8	50.3	51.4	52.7
6	46.6	49.2	48.0	53.5	49.9	51.1
7	43.0	48.6	46.1	50.5	52.3	53.5
8	40.5	41.4	43.9	48.7	52.9	49.2
9	44.5	50.4	50.6	58.0	61.4	62.7
10	40.5	41.4	43.5	49.6	46.8	48.8
11	35.6	42.3	47.1	48.6	47.1	46.7
12	37.2	42.8	46.9	50.8	54.8	55.0

TABLE XXXV

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT VIOLET 47 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	48.1	66.9	68.4	69.7	73.3	77.0
2	47.5	65.1	65.6	65.6	66.5	67.1
3	48.9	68.4	71.2	74.3	74.1	74.8
4	47.5	68.8	68.2	67.3	71.4	75.7
5	51.0	71.1	76.8	83.5	78.2	78.5
6	41.1	60.3	66.0	70.6	71.5	72.4
7	45.0	65.6	68.9	71.8	75.6	79.3
8	50.9	67.1	71.1	75.6	72.8	72.5
9	40.6	58.6	59.2	60.3	65.2	70.5
10	44.8	66.3	71.6	76.4	76.8	78.0
11	42.8	64.3	68.2	72.0	72.7	73.5
12	44.0	69.3	69.8	70.2	73.5	77.6

PART B. UNBLEACHED FABRIC

1	44.2	61.3	61.4	69.2	71.4	73.3
2	42.8	58.8	66.7	65.0	65.6	66.5
3	44.2	59.3	65.0	69.9	71.5	72.9
4	45.6	60.4	67.0	73.1	73.8	75.7
5	41.3	58.1	62.5	65.1	68.8	71.7
6	51.5	67.0	70.5	73.5	76.0	79.9
7	50.9	68.9	74.9	79.6	80.3	82.7
8	40.3	52.8	58.5	62.9	62.7	62.4
9	42.3	63.0	66.2	69.4	73.5	77.0
10	37.3	54.2	56.6	58.4	61.4	64.1
11	34.3	48.9	53.7	57.8	58.7	59.2
12	34.2	50.0	57.5	64.1	65.0	65.9

TABLE XXXVI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT BLUE 14 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	20.7	32.4	38.1	42.6	45.7	49.1
2	20.8	32.7	35.5	42.1	42.6	43.5
3	21.7	32.5	44.7	46.7	46.7	47.8
4	21.8	35.3	46.6	49.6	53.0	54.9
5	23.0	33.5	38.3	46.6	51.7	54.6
6	23.8	33.8	37.5	48.5	46.8	48.3
7	19.7	33.3	36.4	41.4	43.3	48.4
8	23.8	37.2	44.9	49.5	48.0	49.9
9	23.5	37.1	48.5	48.2	48.4	49.3
10	19.1	36.3	39.2	49.2	50.8	52.3
11	23.4	36.4	41.2	48.1	50.1	52.1
12	23.9	35.9	42.4	47.9	48.9	50.2

PART B. UNBLEACHED FABRIC

1	19.8	31.8	33.7	40.9	42.0	42.5
2	21.7	34.4	35.7	42.5	45.7	50.7
3	21.7	33.9	49.4	44.4	46.8	49.1
4	24.1	36.8	41.5	51.8	50.8	58.2
5	22.7	35.6	46.5	43.5	48.0	49.9
6	21.8	33.8	34.8	46.8	46.5	48.0
7	21.1	30.0	35.7	44.1	42.3	49.7
8	20.8	33.6	43.6	43.0	43.1	44.3
9	23.6	34.6	38.8	44.9	50.5	53.9
10	22.0	37.1	44.2	44.9	46.0	46.9
11	23.6	34.7	41.9	49.4	50.9	52.2
12	20.3	31.7	35.8	42.7	46.2	49.5

TABLE XXXVII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT NAVY 252 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	13.8	15.5	15.0	16.1	15.5	15.9
2	13.0	14.0	15.0	16.0	15.8	15.4
3	15.3	14.9	17.0	18.0	18.2	18.8
4	13.0	12.9	14.9	18.6	16.3	16.4
5	13.2	15.5	14.1	15.4	15.3	16.2
6	13.9	17.3	16.6	17.8	16.9	17.3
7	12.7	13.7	13.4	13.8	13.4	14.2
8	12.4	14.6	13.8	14.1	14.1	14.9
9	16.0	16.2	17.1	17.1	17.3	18.6
10	11.9	13.6	15.2	15.3	14.3	14.1
11	13.6	15.9	16.1	16.8	16.0	16.3
12	13.9	17.0	17.6	16.9	16.4	16.6

PART B. UNBLEACHED FABRIC

1	12.7	16.0	16.1	17.4	16.3	15.7
2	14.6	16.0	14.9	15.5	15.8	16.6
3	13.5	14.3	15.5	21.4	17.9	17.2
4	14.0	15.2	17.5	18.1	16.4	17.5
5	12.0	15.3	14.5	17.8	16.1	16.7
6	12.5	14.1	15.4	16.4	15.4	16.2
7	13.5	15.5	15.6	15.5	15.5	16.4
8	13.2	14.5	16.1	16.7	16.3	16.9
9	13.9	15.5	15.1	16.6	16.3	16.5
10	12.3	14.6	15.2	16.4	15.2	15.5
11	11.6	15.0	15.4	17.0	16.5	17.5
12	13.1	15.8	16.3	17.8	16.2	16.3

TABLE XXXVIII

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT GREEN 68 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	24.9	31.6	28.5	32.1	32.5	33.2
2	28.7	33.0	36.0	35.9	36.6	37.6
3	30.6	34.2	32.2	37.2	38.0	39.0
4	29.8	22.0	33.5	37.5	37.5	37.9
5	26.9	32.7	31.8	31.9	32.5	34.1
6	22.1	22.2	21.7	23.4	23.4	24.5
7	23.1	32.8	32.0	32.2	32.4	33.2
8	24.5	28.2	30.5	34.9	35.2	35.2
9	29.1	35.3	36.0	36.4	47.3	40.4
10	29.2	34.3	35.0	37.1	37.0	37.6
11	27.2	28.7	29.0	34.4	34.4	35.1
12	24.8	29.5	30.4	29.7	30.8	32.9

PART B. UNBLEACHED FABRIC

1	20.4	27.3	24.1	28.3	28.7	29.9
2	16.3	21.1	23.7	25.4	25.8	26.6
3	20.2	28.0	26.7	30.5	30.7	30.5
4	28.5	34.3	34.0	37.1	37.2	37.5
5	15.6	21.7	22.3	22.5	22.5	23.3
6	16.4	21.9	22.1	21.5	22.7	23.7
7	21.1	28.3	29.4	29.2	29.5	30.3
8	21.0	25.2	26.1	26.9	27.9	30.3
9	21.5	29.0	29.9	29.5	31.0	31.4
10	22.4	28.0	25.6	27.1	27.5	29.1
11	20.6	24.2	25.0	25.7	26.9	28.3
12	20.5	27.0	26.4	29.5	29.7	30.6

TABLE XXXIX

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT OLIVE 70 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	28.3	33.0	36.1	38.8	39.6	43.7
2	29.6	34.7	35.0	40.6	42.7	40.7
3	30.7	33.0	36.7	39.1	41.1	42.4
4	29.9	31.7	35.9	35.1	34.5	38.9
5	38.0	36.1	39.7	45.1	46.5	45.4
6	36.8	39.5	44.0	44.8	45.7	52.0
7	30.4	34.6	37.7	41.6	46.9	43.4
8	25.8	31.7	34.9	37.4	34.2	37.0
9	32.1	33.8	37.2	40.3	41.0	40.4
10	35.8	30.4	36.9	34.6	40.4	40.5
11	35.8	37.3	41.2	41.8	45.3	45.9
12	26.6	29.1	35.6	35.5	39.2	42.5

PART B. UNBLEACHED FABRIC

1	29.3	29.9	34.2	38.7	42.3	44.3
2	27.2	32.5	33.8	33.7	36.9	41.7
3	27.6	32.2	37.2	40.9	41.8	44.2
4	32.4	33.9	32.5	35.7	42.8	41.2
5	29.2	32.5	33.4	34.2	38.7	40.9
6	28.8	40.1	43.3	44.8	44.8	51.2
7	29.8	33.0	33.0	33.2	38.7	39.2
8	31.9	36.9	40.5	47.2	46.8	51.6
9	35.4	41.8	45.1	46.9	41.3	48.7
10	29.5	30.7	32.7	34.7	35.3	37.9
11	28.8	29.5	32.2	34.5	37.0	36.8
12	29.1	30.5	35.0	35.5	37.7	37.6

TABLE XL

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT BROWN 3 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	26.4	30.8	31.8	36.1	36.3	37.4
2	27.2	30.8	30.3	31.4	33.1	34.7
3	24.9	33.9	31.3	36.3	37.4	38.7
4	24.4	31.6	29.6	36.3	34.1	35.1
5	27.3	25.5	29.8	33.9	39.8	36.4
6	29.0	34.0	32.9	35.4	38.7	38.5
7	28.2	29.6	31.3	31.0	36.5	38.3
8	28.4	32.0	32.4	34.5	34.8	35.8
9	27.3	34.3	34.4	34.5	35.6	37.3
10	28.4	30.7	32.6	36.8	35.3	35.8
11	25.4	28.5	30.5	34.1	33.8	33.8
12	27.5	34.0	32.0	33.5	35.0	36.5

PART B. UNBLEACHED FABRIC

1	23.8	30.0	29.5	32.8	34.0	35.4
2	26.7	31.5	32.4	38.2	39.3	40.4
3	21.7	31.5	30.2	34.7	36.6	38.1
4	26.0	31.8	34.7	37.9	38.3	39.1
5	24.4	31.9	30.3	33.5	35.6	36.9
6	26.8	32.4	31.9	35.9	43.8	38.5
7	26.9	30.1	29.4	34.7	33.9	34.7
8	24.4	27.7	31.0	32.8	33.4	34.3
9	26.6	29.9	30.8	35.7	34.4	36.3
10	23.7	25.6	31.3	32.0	34.1	36.3
11	23.4	28.9	23.7	37.7	37.9	38.7
12	24.5	29.8	31.9	35.7	32.4	36.5

TABLE XLI

SPECTROPHOTOMETRIC MEASUREMENTS IN TERMS OF REFLECTANCE RATINGS OF COTTON FABRICS DYED WITH DIRECT BLACK 91 AFTER A SPECIFIED NUMBER OF LAUNDERINGS AT 160° F.

PART A. BLEACHED FABRIC

Cotton Lot Number	NUMBER OF LAUNDERINGS					
	0	5	10	15	20	25
1	13.0	15.2	10.1	19.5	20.3	20.3
2	11.9	15.8	19.2	21.2	21.3	22.2
3	12.2	16.4	18.0	19.2	20.0	20.6
4	13.7	19.7	19.7	18.3	20.9	25.0
5	14.6	20.1	20.7	22.5	23.2	24.1
6	15.7	19.2	21.7	23.9	25.4	27.6
7	16.0	20.6	21.3	23.0	23.1	23.6
8	16.4	22.9	23.0	23.9	26.1	29.2
9	15.1	21.1	21.9	22.6	23.5	25.0
10	12.6	13.5	17.7	19.6	19.3	20.1
11	13.2	16.5	19.1	21.2	21.6	23.5
12	16.3	17.8	19.3	21.1	23.0	25.1

PART B. UNBLEACHED FABRIC

1	14.1	19.2	20.8	22.0	23.1	24.9
2	12.5	15.6	17.4	18.9	19.6	20.8
3	16.1	25.3	25.4	25.5	27.0	29.7
4	13.1	18.4	18.6	18.6	20.5	23.2
5	15.0	19.4	21.4	23.8	24.6	26.2
6	14.8	21.3	20.7	20.3	22.2	24.5
7	14.3	16.9	18.9	20.4	21.0	21.6
8	15.9	21.6	24.5	27.2	28.2	30.0
9	15.5	16.6	17.5	18.5	19.0	19.7
10	14.1	16.7	18.8	19.4	19.9	20.7
11	17.6	22.9	23.9	25.8	27.0	29.6
12	16.1	19.4	21.3	24.0	26.6	29.4