A COMPARISON OF THE SERVICE QUALITIES OF CERTAIN COTTON MATERIALS

by

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TABLE OF CONTENTS

INTRODUCTION

Cotton fabrics are recommended to high school students for use in their clothing classes because they are inexpensive and considered to be a material that will withstand hard wear and repeated launderings. Little reliable information is available which will aid the instructor in guiding students in their selection of satisfactory wash fabrics.

The selection of fabrics should be based upon the relation between price and service qualities. A fabric should not change in appearance, size, or texture when subjected to wear or cleaning and should resist deterioration for a reasonable length of time. With the increased use of color in cotton fabrics, the problem of selection has become more difficult.

There are several methods used for the application of color to cloth. In the construction of gingham, the yarns are dyed in one or more colors, then woven into the pattern. Plain colored fabrics are nearly always woven in the grey and dyed in the piece; however, when a pastel tint is required, the color is applied by means of a pad roller

which distributes color to the fabric evenly. In prints, the color is applied in design only. Cotton fabrics purchased by high school girls are usually one of these three types; yarn-dyed, piece-dyed, or printed.

The purpose of the present study was to compare the service qualities of certain cotton fabrics that were available in Dodge City, Kansas in 1938; to determine the effect on the service qualities of fabrics, of the method of applying the color; and to determine the effect of pleating and starching in laundering. It is hoped that the information gained in this study will aid those advising high school girls in purchasing dress materials and will furnish consumer information on the selection of fabrics.

REVIEW OF LITERATURE

A number of investigators report findings concerning the wearing qualities of cotton fabrics. These studies include the effect of sunlight, of washing, and of ironing on the color, strength, and shrinkage of cotton fabrics.

Bruner and Roberts (2) compared the qualities of percales obtained on the market with government specifications which are as follows: width 36 in. ± 1/4 inch; thread

count 85 x 72 with variables plus any number or minus three; tensile strength, using grab method, 45 lbs. warp and 30 lbs. filling; weight per square yard 3.1 oz. + 5 percent; sizing 3 percent of weight.

Six pieces of percale at 25 cents per yard were compared with seven pieces at 17 cents per yard. The percales studied were of similar thread count, width, percent of sizing, and fastness to laundering, even when not guaranteed to comply with the government specifications. They showed considerable variation in weight per square yard and breaking strength. None of the colors were fast to Kansas sunlight. The fabrics sold under the certification plan did not meet the specifications of the Bureau of Standards for percales purchased by the government, and were of no better quality or appearance than the other materials analyzed.

Coles and Kirkpatrick (3) reported the result of a study to determine the relative fastness of color in guaranteed and non-guaranteed cotton fabrics, and to encourage the consumer to improve her standards of selection. One hundred three fabrics were tested. Of these, 54 were guaranteed fast color and 49 were not. Twenty four of the non-guaranteed fabrics were sold under brand names and twenty

five were not.

Guaranteed fabrics, in general, were more reliable than non-guaranteed; and those sold under brand names were slightly more reliable than the non-branded fabrics as to fastness of color in laundering and in sunlight. The range in price of guaranteed materials was higher but they were more reliable. But there was a wide variation in reliability of color fastness, so they concluded that consumers cannot, as yet, depend absolutely on guarantee. In a majority of cases, there was a close relation between fastness of color to light and to laundering.

Ginter, Shadduck, Partlow, and Pearson (5) studied the effect of commercial and home laundry methods on five cotton muslins. Results were analyzed to show both the effects due to washing and those due to ironing. The commercial washing methods caused less decrease in the strength of fabrics during the first fifteen launderings but more thereafter than did home methods. The effect of washing on shrinkage was similar with all methods. The ironer used in commercial methods had more pronounced effects than either the hand or rotary iron used in the home, as was shown by greater decrease in weight, greater loss in strength of the filling yarns, and by decreased lengthwise

but increased fillingwise shrinkage. Hand ironing produced greater decrease in length warpwise than fillingwise. In the commercial process, ironing was responsible for as much or greater loss of strength fillingwise than washing. In the home method, the washing procedure seemed to be more responsible for the changes, except in the first few launderings.

Howarth (8) also made a study of the effect of power and home launderings on certain cotton fabrics. In three-fourths of the cases, the loss in tensile strength was greater in the portions laundered in the home management house. All fabrics showed some color change for all laundering methods. Power methods seemed to have no greater effect on strength or on color than home methods.

Grimes (6) listed the factors influencing fading by light as: quality of light, relative humidity, temperature, atmospheric impurities, nature of fiber, nature and depth of dye, and finishes of the material. The factors influencing tendering by light she lists as: nature of light, atmospheric conditions, nature of material, nature of dyes and finishes, and chemical changes. Materials dyed with vat dyes were much more fast to color and tendered less in sunlight than materials dyed with direct dyes. The breaking

strength of the fabrics were affected more by the number of hours of exposure to the sunlight than by any other factor. Price was no indication of color fastness. All fabrics, whether white or colored, underwent some color change during exposure to sunlight. It was evident that there was no absolute fast color, although, in general, darker colors were found to be more fast to light than lighter colors.

Dr. Sch. (11) found the factors controlling fading to be: intensity of light falling on the dyed material; the relative humidity of the air in contact with the dyed material at the time of exposure to the light; the temperature of the air, and the temperature of the exposed surface of the cloth. In one experiment, it was found that fading during a certain length of time at 90 percent relative humidity was the same as when exposed three times as long at 30 percent relative humidity. In another experiment, fading was 75 percent greater at 50 degrees C. than at 10 degrees C. when the humidity was kept constant.

Ironing as a factor in the deterioration of cotton fabrics has been considered recently (9). Tests were made on three grades of cotton sheeting. The influence of pressure was found to be more marked at high ironing temperatures than at low temperatures. Time seemed to be a

greater deteriorating factor than pressure. Ironing at high temperature with sliding contact displaced the yarns and produced noticeable stretching as compared with low temperature and low pressure.

McTavish (10) studied the wearing qualities and shrinkage of different priced ginghams. Three groups of ginghams were used ranging in price from 10 to 35 cents per yard. Without exception the number of the threads per inch, both warp and filling, increased with the price. Shrinkage of the warp decreased with rise in price, but this was not always true with the filling threads. The shrinkage, however, in the filling yarns was hardly enough to consider in any price gingham. The breaking strength did not increase with the price. The number of threads per inch influenced shrinkage but had no direct bearing on wearing qualities. "The price asked is usually directly proportional to the number of threads per inch and the best the purchaser can do is judge the value of her purchase by thread count and the suitability of the piece to her purpose."

Schaenzer and Hardy (12) gave the results of an intensive study made by the homemaker's section of the District of Columbia Home Economics Association. Thirty seven

cotton dress materials, varying in price, weave, color, and weight, were purchased from local stores to determine how certain characteristics showed up under tests and how many of these facts were revealed by what could be learned about them at the time of purchase.

Analysis showed that little relation existed between the price and the color fastness, or shrinkage. In some cases, the color lost in commercial laundering was as much as in that done at home, but in most cases it was less in commercially laundered fabrics. However, the commercial laundry weakened the fabric more than the home laundry.

Snyder and Winegar (13) compared the effect of home and commercial laundry methods on cotton fabrics. The effect of washing as measured by breaking strength varied in the warp and filling yarns. This might have been due to the difference in finish or twist of yarn. Washing by commercial laundries decreased strength more than home launderies. The difference may be due to the bleaching powders used by commercial laundries.

A recent study on variables in 80 square percale (14) stated that this means the thread count in the grey, and when the fabric is bleached, sized, calendered, and printed, it is longer and narrower than originally because material

is stretched lengthwise in finishing.

In case of 80 square percale, the manufacturer uses a material 40 inches wide in the grey in order to produce a 36 inch material finished. This change in length and width affects the thread count, giving more warps and fewer fillings per inch. The count in the finished cloth is more like 84 or 82 warp, and 76 or 72 filling.

Five samples were tested for thread count and tensile strength to study price versus quality. All but one fabric was within the limits set by the U. S. Federal Specifications (14), (85 warp and 72 fillings with a minus tolerance of 3 and any plus tolerance). This specification sets a minimum breaking strength of 45 pounds in the warp and 30 pounds in the filling threads. Fabrics with high thread count were not necessarily high in tensile strength; neither did low count always mean low tensile strength. The fabrics of medium thread count and low price range were found to have the greatest tensile strength. The piece costing 17 cents per yard had the highest breaking strength. The most expensive piece had the highest thread count but was the lowest tensile strength.

In so far as these tests may be considered as showing typical conditions, they indicate that price cannot be re-

lied on by the consumer as a guide to quality in buying percale.

White (15) reported the following new shrinkage rules for woven cotton goods. The Federal Trade Commission in June, 1938 passed some rules for the purpose of eliminating and preventing unfair practice concerning the preshrunk character of woven cotton materials. These rules apply to garments made from cotton goods as well as piece goods. The new rules define "residual shrinkage" as shrinkage remaining in the fabric after it has undergone a shrinking process. The test recommended for determining residual shrinkage is contained in Commercial Standard CS 59-36, woven dress fabrics, testing and reporting. Labeling is not compulsory but provision is made for any labels that are used. All woven fabrics labeled with terms as "full shrunk", and "will not shrink" must have been fully shrunk so no residual shrinkage remains left in them. Partially shrunk fabrics may be labeled as "shrunk", "pre shrunk", or similar terms, provided additional information is given concerning the percent they will shrink in both warp and filling or in the direction having the greatest shrinkage.

METHOD OF PROCEDURE

Through correspondence with Thomas Nelson, Dean of the Textile School, North Carolina State College; and John Hoye, Thurston Cutting Corporation, New York, it was decided to classify ginghams as fabrics made from yarns dyed before weaving; piece-dyed as fabrics woven in the grey and then dyed solid color as desired; and prints as fabrics with the design printed on one side of the cloth.

Using this classification, fabrics dyed by each of these three methods were selected for this study. Three yards each of four different ginghams (yarn-dyed); four plain colored percales (piece-dyed); and four cotton prints (surface printed) were purchased in Dodge City. All of the materials were plain weave and as nearly the same weight, thickness, and width as could be obtained. All materials were sold as color fast fabrics. The ginghams were $0.29 per yard and the plain colors and prints were $0.19 per yard.

Samples of materials used in this study are shown in Plates I to VI. The numbers given to the fabrics in these plates are used in all charts when referring to specimens.

All laundering and exposure to elements was done in Dodge City.

The fabrics were analyzed for width, thickness, thread count, weight per square yard, breaking strength, elongation, and yarn number according to the methods approved by Committee D-13 on Textile Materials (4).

EXPLANATION OF PLATE I

Specimens 1a and 2a. Print controls.

Specimens 1b and 2b. Fabrics after 3 months' exposure to room light.

Specimens 1c and 2c. Fabrics after 20 launderings.

Specimens 1d and 2d. Fabrics after 120 hours' exposure to direct sunlight.

PLATE I

1a

2a

1b

2b

1c

2c

1d

2d

EXPLANATION OF PLATE II

Specimens 3a and 4a. Print controls.

Specimens 3b and 4b. Fabrics after 3 months' exposure to room light.

Specimens 3c and 4c. Fabrics after 20 launderings.

Specimens 3d and 4d. Fabrics after 120 hours' exposure to direct sunlight.

PLATE II

3a

4a

3b

4b

3c

4c

3d

4d

EXPLANATION OF PLATE III

Specimens 5a and 6a. Piece-dyed controls.

Specimens 5b and 6b. Fabrics after 3 months' exposure to room light.

Specimens 5c and 6c. Fabrics after 20 launderings.

Specimens 5d and 6d. Fabrics after 120 hours' exposure ro direct sunlight.

PLATE III

5a

6a

5b

6b

5c

6c

5d

6d

EXPLANATION OF PLATE IV

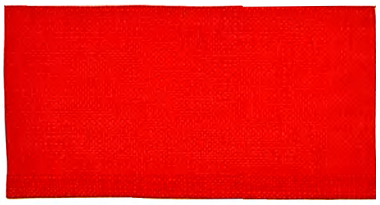
Specimens 7a and 8a. Piece-dyed controls.

Specimens 7b and 8b. Fabrics after 3 months' exposure to room light.

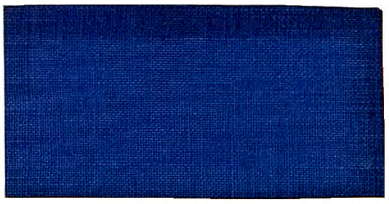
Specimens 7c and 8c. Fabrics after 20 launderings.

Specimens 7d and 8d. Fabrics after 120 hours' exposure to direct sunlight.

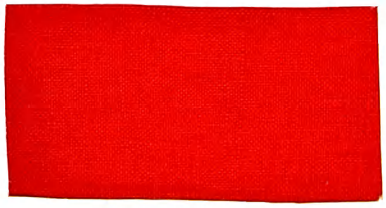
PLATE IV



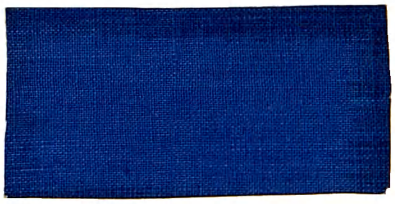
7a



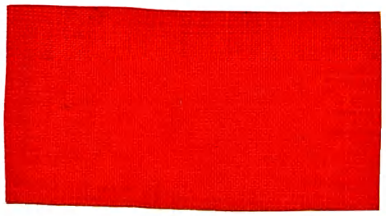
8a



7b

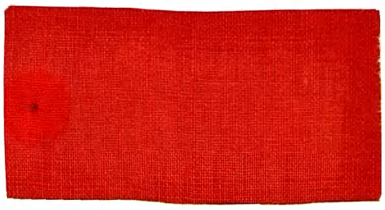


8b



7c

8c



7d

8d

EXPLANATION OF PLATE V

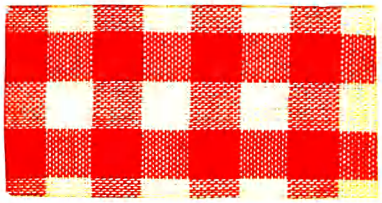
Specimens 9a and 10a. Yarn-dyed controls.

Specimens 9b and 10b. Fabrics after 3 months' exposure to room light.

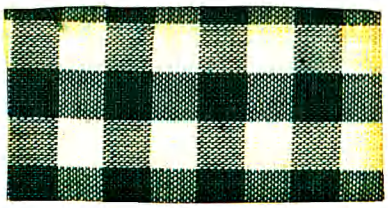
Specimens 9c and 10c. Fabrics after 20 launderings.

Specimens 9d and 10d. Fabrics after 120 hours' exposure to direct sunlight.

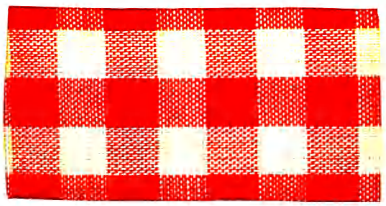
PLATE V



9a

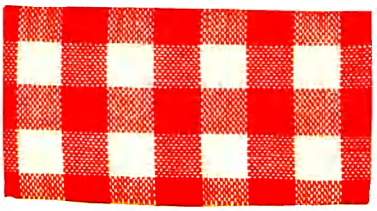


10a



9b

10b



9c

10c

9d

10d

EXPLANATION OF PLATE VI

Specimens 11a and 12a. Yarn-dyed controls.

Specimens 11b and 12b. Fabrics after 3 months' exposure to room light.

Specimens 11c and 12c. Fabrics after 20 launderings.

Specimens 11d and 12d. Fabrics after 120 hours' exposure to direct sunlight.

PLATE VI

11a

12a

11b

12b

11c

12c

11d

12d

The weight per square yard was determined on a dry basis. The breaking strength and stretch were made in a room in which the relative humidity was maintained at 66 percent with a tolerance of ±2, and a temperature of 80° F. with a tolerance ±2 degrees. After conditioning, the specimens were broken in the Scott Tester and the load elongation autographically recorded.

The twist of the yarn was determined in the Suter Twist Tester according to the method given in Handbook of Industrial Fabrics (7). The cotton method of determining yarn number was used. The percentage of crimp of the yarns was determined by use of camera lucida drawings of the yarns as they exist in the fabrics.

Laundering to determine changes in color, strength, and size was done by the hand method. Twenty launderings were accepted as an average number of launderings for garments in one year; therefore, each specimen was laundered twenty times. City water at a temperature of about 160° F. and sufficient mild soap to make a permanent suds were used. All specimens were washed in two suds for five minutes each and given three five-minute rinses in lukewarm water.

The specimens for determining shrinkage were cut, marked, and measured according to Committee D-13 on Textile

Materials (4). These specimens, twenty inches square, after washing were hung to dry on a wire clothes line in a well lighted, well ventilated room. After drying, they were sprinkled, rolled in a turkish towel and allowed to stand for thirty minutes before ironing. Ironing was done with a hand electric iron set at the temperature designated for cotton. Care was taken to avoid stretching the material in either direction. Measurements were made within the marked area to determine any change in size. The shrinkage was expressed in inches per square yard, and in percentage. These specimens were cut into steips which were used in the determination of the effect of laundering on the breaking strength of the fabrics.

Another set of specimens, each twenty inches square, was cut and laundered by the same method except that the specimens were starched each time after the last rinse. A cooked starch was prepared and a sufficient amount used to give the fabrics the desired stiffness. All specimens were placed in the starch at the same time. These specimens were dried, sprinkled, and ironed in the same manner as the unstarched specimens. After twenty launderings, these specimens were laid away for six months before the breaking strength was obtained.

A comparison was made of the breaking strength of the starched and unstarched specimens to determine whether or not starch affected the fabrics within a six months' period.

One-half inch pleats were basted into four specimens of each fabric. In two of the specimens, the pleats ran parallel to the warp yarns and in the other two they ran parallel to the filling yarns. One set of each was laundered without starch. The other set was starched in each laundering. After twenty launderings, the breaking strength of these specimens was obtained. A comparison was made of the breaking strength of the starched and non-starched pleated fabrics; and the pleated fabrics with those not pleated.

The fastness of color to laundering and to light was determined for these fabrics using the visual method. Any change in color was rated as not noticeable, slight, pronounced, or undesirable. Twenty persons rated the fabrics and the number of times a specimen was placed under each heading was counted and a table of combined ratings made. These are shown in Table 9.

The specimens which had been laundered twenty times were examined for any fading due to laundering.

The sun tests were made by the Standard Sun Test (1, p. 171). A specimen from each material was placed in the sun box and exposed to direct sunlight for 120 hours to determine the fastness of the colors to sunlight. Exposures were made between August 24 and September 14. The temperature and humidity on days of exposure are given in Table 1.

Another set of specimens was exposed to the light in a northwest room for three months and any change in color noted.

FINDINGS AND DISCUSSIONS

The tensile strength of the yarn-dyed both warpwise and fillingwise was more nearly balanced than in the other fabrics studied. In the yarn-dyed, the average breaking strength fillingwise was 34.9 pounds, and warpwise it was 43.6 pounds. In the prints, the average breaking strength was 28.3 fillingwise and 43.5 warpwise. The piece-dyed fabrics showed a variation in strength of 29.3 fillingwise and 42.5 warpwise. There was little difference in the warpwise and fillingwise strength of the three types of fabrics but the higher breaking strength fillingwise of the

Table 1. Conditions of humidity and temperature during the time specimens were exposed to the direct sunlight.

Date	Time a.m.	Time p.m.	Temperature degrees Fahrenheit	Humidity at noon percent
August				
24	10	4	88- 98	21
25	10	4	90-100	18
26	10	4	78- 95	47
27	9	5	88- 98	23
28	9	4	89-100	24
29	10	4	82- 92	51
30	10	4	85- 94	26
31	10	4	84- 94	32
September				
1	10	4	79- 88	34
5		1-4	73- 85	62
6	8	4	77- 86	54
7	8	4	81- 89	47
8	8	4	82- 90	39
9	8	4	84- 93	36
10	9	3	86- 93	33
11	9	3	82- 90	42
12	8	4	78- 87	55
13	8	4	71- 81	60

yarn-dyed would indicate that they were the strongest fabrics.

Although the yarn-dyed showed a slightly higher breaking strength than the other two types of fabrics, they had fewer threads per inch. There were 56 filling yarns and 72 warp yarns per inch in the yarn-dyed; 80 filling yarns and 88 warp yarns per inch in the piece-dyed; and 72 or 76 filling yarns and 80 or 86 warp yarns per inch in the prints. Hence, a high thread count does not indicate high breaking strength.

The yarn number of both filling and warp yarns in the yarn-dyed was very nearly the same; in the other two groups the filling yarns were finer than the warp yarns.

The yarns of all fabrics studied had a Z twist. In the prints and in the piece-dyed, the warp yarns showed a higher twist than the fillings; the warp yarns having 27 or 28 turns per inch and the filling yarns having 23 or 25 turns per inch. In every case, the yarn-dyed showed the same number of twists in both the warp and filling yarns; 21 turns per inch.

The yarn-dyed were slightly thicker than the prints and piece-dyed fabrics. The thickness of the yarn-dyed was 0.0013 inch, and the others ranged in thickness from

0.0012 to 0.0015 inch.

A summary of the results of fabric analysis is given in Table 2.

The shrinkage, measured after twenty launderings, in every case was greater warpwise than fillingwise. The yarn-dyed shrank much more than the other fabrics, probably due to a lower thread count and a lower twist in the yarns. The piece-dyed fabrics shrank slightly more than the prints. The average shrinkage fillingwise for the yarn-dyed was 3.82 percent; for the piece-dyed 0.63 percent; and for the prints 0.61 percent. In the warpwise yarns, the yarn-dyed shrank 7.20 percent; the piece-dyed 4.8 percent; the prints 4.3 percent. A summary of the shrinkage of the fabrics due to laundering will be found in Table 3.

The yarn-dyed were weakened the least and the prints the most by laundering (Table 4). In every case, the fabrics were weakened more warpwise than fillingwise. The average percent loss in breaking strength due to laundering of the prints was 38.3 percent warpwise and 35.6 percent fillingwise. The piece-dyed fabrics lost 33.4 percent warpwise and 22.5 percent fillingwise. The breaking strength of the yarn-dyed was lowered 29.5 percent

Table 2. Analysis of twelve control fabrics.

Specimen	Width: inches	Price	Thickness: inches	Thread count per inch: warp	Thread count per inch: filling	Breaking strength pounds: warp	Breaking strength pounds: filling	Elongation percent: warp	Elongation percent: filling	Twist in yarns direction: warp	Twist in yarns direction: filling	Twist in yarns per inch: warp	Twist in yarns per inch: filling	Weight per sq. yd. ounces	Yarn number: warp	Yarn number: filling
							Prints									
1	35.5	$0.19	0.00115	86	76	47.1	26.9	3.0	10.0	Z	Z	28	25	3.319	29.0	45.3
2	35.5	0.19	0.0012	86	76	41.8	24.2	4.6	11.0	Z	Z	28	25	3.261	33.4	40.7
3	35.5	0.19	0.0012	86	76	45.9	36.3	5.0	11.0	Z	Z	28	25	3.489	34.7	41.0
4	35.5	0.19	0.00115	80	72	39.4	26.0	4.2	12.0	Z	Z	27	23	5.301	32.2	37.8
							Piece-dyed									
5	35.5	0.19	0.00115	88	80	43.5	29.9	5.3	12.0	Z	Z	28	25	2.608	34.0	41.4
6	35.5	0.19	0.00115	88	80	42.2	30.2	8.0	10.0	Z	Z	28	23	3.054	34.8	46.7
7	35.5	0.19	0.00115	88	80	44.5	32.5	5.0	10.0	Z	Z	28	23	3.335	32.5	42.0
8	35.3	0.19	0.00115	88	80	39.9	24.8	6.0	13.0	Z	Z	28	23	3.218	34.0	45.0
							Yarn-dyed									
9	35.0	0.29	0.0013	72	56	45.7	37.6	7.7	8.5	Z	Z	21	21	2.912	32.2	31.1
10	35.0	0.29	0.0013	72	56	44.7	35.3	7.0	7.2	Z	Z	21	21	3.037	33.4	27.3
11	35.0	0.29	0.0013	72	56	42.6	34.6	8.7	6.0	Z	Z	21	21	3.020	29.3	32.6
12	35.0	0.29	0.0013	72	56	41.5	32.2	8.0	9.0	Z	Z	21	21	3.951	30.9	32.1

Table 3. Shrinkage of 12 fabrics as expressed in inches per yard and as percentage loss of the dimension before laundering.

Specimen	Size (inches)				Thread count per inch				Shrinkage			
	Control		Laundered		Control		Laundered		Percent		In. per yd.	
	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling
					Prints							
1	18	18	17.25	17.75	86	76	90	82	4.2	1.40	1.50	0.50
2	18	18	17.13	17.94	86	76	86	84	4.8	0.35	1.75	0.12
3	18	18	17.25	17.94	86	76	86	82	4.2	0.35	1.50	0.12
4	18	18	17.25	17.94	80	72	80	76	4.2	0.35	1.50	0.12
Average	18	18	17.22	17.90	84.5	75	85.5	81	4.3	0.61	1.55	0.22
					Piece-dyed							
5	18	18	17.00	17.94	88	80	88	84	5.50	0.35	2.00	0.12
6	18	18	17.00	17.94	88	80	88	84	5.50	0.35	2.00	0.12
7	18	18	17.00	17.66	88	80	90	84	5.50	0.92	2.00	0.33
8	18	18	17.50	17.66	88	80	90	82	2.80	0.92	1.00	0.33
Average	18	18	17.10	17.80	88	80	89	83.5	4.80	0.63	1.80	0.22
					Yarn-dyed							
9	18	18	16.50	17.37	72	56	76	64	8.33	3.47	3.00	1.25
10	18	18	16.62	17.50	72	56	74	64	7.64	2.80	2.75	1.00
11	18	18	17.06	17.13	72	56	78	60	5.20	4.80	1.87	1.75
12	18	18	16.62	17.25	72	56	76	60	7.64	4.20	2.75	1.50
Average	18	18	16.70	17.31	72	56	76	62	7.20	3.82	2.59	1.37

warpwise and 17.2 percent fillingwise.

The addition of starch to the fabric in laundering increased the breaking strength (Table 4). This increase was greater fillingwise than warpwise. In the yarn-dyed and the piece-dyed, the starched fabrics were stronger fillingwise after 20 launderings than the controls. The starch seemed to act as a glue which held the yarns together. In the specimens not starched, the yarns slipped and broke in an irregular line across the strip. There was less slippage of yarns in the starched fabrics and they broke straight across the strip almost as though they had been cut.

Pleating lowered the breaking strength of the starched fabrics, but did not weaken the non-starched fabrics (Table 4). Two-thirds of the starched, pleated specimens broke across the crease of pleating but the non-starched, pleated specimens did not break in this crease.

Sunlight did not prove to be as great a deteriorating factor as laundering (Table 4). The piece-dyed and prints were weakened more fillingwise than warpwise by direct sunlight; but the opposite was true with the yarn-dyed. In the prints, sunlight was responsible for a 10.8 percent loss of breaking strength warpwise and 18.0 percent loss

Table 4. Breaking strength of 12 fabrics tested, expressed in pounds, after subjection to various treatments.

Specimen	Control warp	Control filling	Laundered plain: No starch warp	Laundered plain: No starch filling	Laundered plain: Percent loss from control warp	Laundered plain: Percent loss from control filling	Laundered plain: Starched warp	Laundered plain: Starched filling	Laundered plain: Percent variation from control warp	Laundered plain: Percent variation from control filling	Laundered and pleated: No starch warp	Laundered and pleated: No starch filling	Laundered and pleated: Percent variation from control warp	Laundered and pleated: Percent variation from control filling	Laundered and pleated: Starched warp	Laundered and pleated: Starched filling	Laundered and pleated: Percent variation from control warp	Laundered and pleated: Percent variation from control filling	Exposed to sunlight: warp	Exposed to sunlight: filling	Exposed to sunlight: Percent loss from control warp	Exposed to sunlight: Percent loss from control filling
Prints																						
1	47.1	26.9	24.5	18.8	26.7	30.1	33.3	25.1	-29.3	- 6.7	36.0	21.0	-23.5	-21.9	38.8	33.7	-17.6	+25.3	41.6	23.5	11.4	12.6
2	41.8	24.2	31.5	20.5	25.1	13.6	37.9	34.9	- 9.1	+25.5	34.2	25.9	-18.1	+ 2.8	40.8	25.7	- 2.3	+ 6.2	37.1	20.6	11.2	14.8
3	45.9	36.3	29.5	17.6	35.7	46.0	34.2	27.7	-25.5	-23.7	32.8	22.7	-28.5	-37.4	37.3	26.6	-18.7	-26.7	40.9	29.3	10.1	19.3
4	39.4	26.0	20.6	16.1	47.3	38.0	31.1	22.0	-21.0	-15.4	27.9	18.4	-29.2	-31.6	30.7	16.1	-22.0	-38.0	35.5	19.7	9.1	24.2
Average	43.5	28.3	26.5	18.2	38.3	35.6	34.1	27.4	-21.6	- 3.2	32.4	22.0	-24.8	-22.2	36.9	25.5	-15.2	- 9.1	38.8	23.3	10.8	18.0
Piece-dyed																						
5	43.5	29.9	26.8	19.0	38.3	36.4	39.6	30.6	- 8.9	+ 2.3	22.5	25.7	-43.2	-14.0	31.2	27.0	-28.2	- 9.7	38.5	25.4	11.4	15.0
6	42.2	30.2	30.0	27.1	28.3	10.2	34.7	34.0	-17.7	+ 5.9	33.9	26.0	-19.6	-13.9	30.2	29.9	-28.4	- 1.0	34.6	22.9	17.1	24.1
7	44.5	32.5	33.7	25.3	24.2	22.1	40.4	31.4	- 9.2	- 3.3	31.6	20.8	-29.0	-36.0	27.7	18.4	-37.7	-43.3	37.7	24.1	13.0	25.7
8	39.9	24.8	22.8	19.5	35.3	21.3	32.7	22.8	-18.0	- 8.0	35.9	26.7	-10.0	+ 7.6	35.5	27.4	-11.0	+10.4	34.0	21.2	14.8	14.5
Average	42.5	29.3	28.3	22.7	33.4	22.5	36.7	29.7	-12.9	+ 4.7	30.9	24.8	-25.8	-15.5	31.1	25.7	-26.7	-12.5	36.2	23.4	14.8	20.1
Yarn-dyed																						
9	45.7	37.6	31.4	27.6	31.3	26.6	42.3	39.6	- 7.4	+ 5.3	31.7	28.7	-30.6	-23.7	32.1	35.2	-29.7	- 6.4	41.5	35.3	9.2	6.1
10	44.7	35.3	31.6	32.6	29.3	7.6	39.0	39.0	-12.7	+10.4	33.7	32.7	-24.6	- 7.3	35.9	36.4	-19.7	+ 3.1	34.5	32.0	22.7	9.3
11	42.6	34.6	29.1	26.9	38.7	22.2	39.1	36.5	- 8.4	+ 5.5	35.8	31.7	-15.8	- 8.3	36.2	32.7	-15.0	- 5.5	33.1	30.5	20.0	11.8
12	41.5	32.2	30.7	28.6	26.2	11.1	40.4	37.5	- 2.6	+16.4	29.8	27.3	-28.1	-15.2	31.3	31.5	-24.5	- 5.7	34.9	30.1	15.8	6.5
Average	43.6	34.9	30.7	28.9	29.5	17.2	40.2	38.2	- 9.4	+ 9.2	32.7	30.1	-24.9	-13.8	33.9	33.9	-22.3	- 1.6	36.0	31.9	17.4	8.4

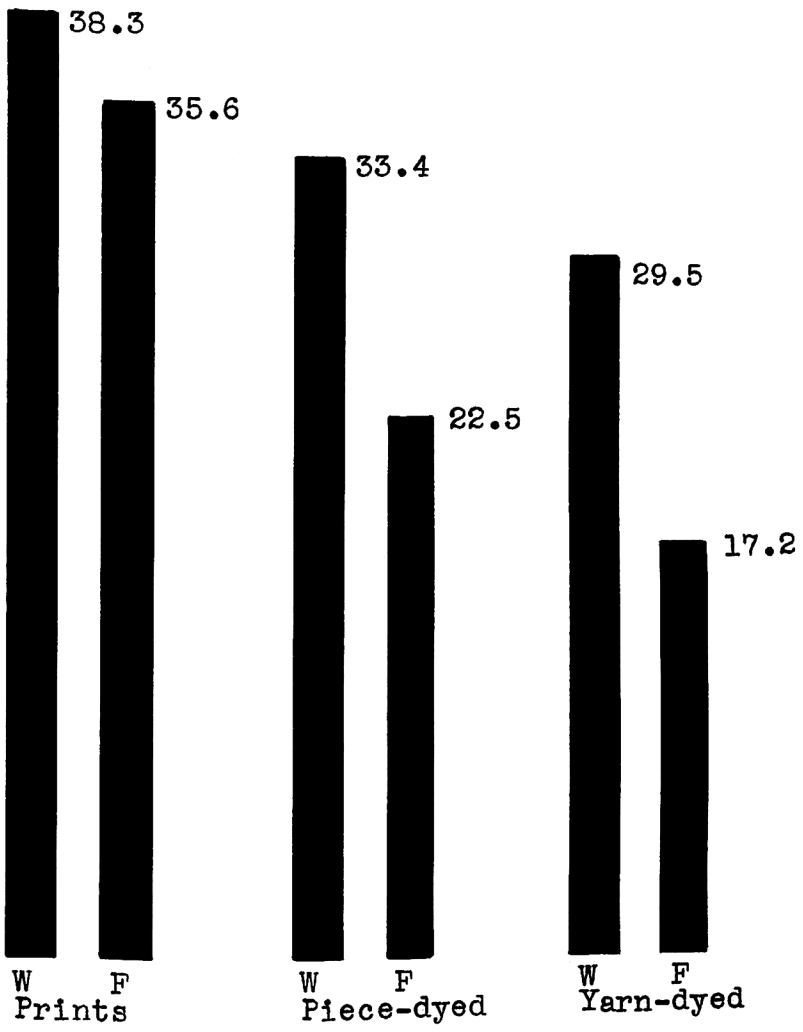


Fig. 1. Percentage of loss of tensile strength due to laundering. W, warp. F, filling.

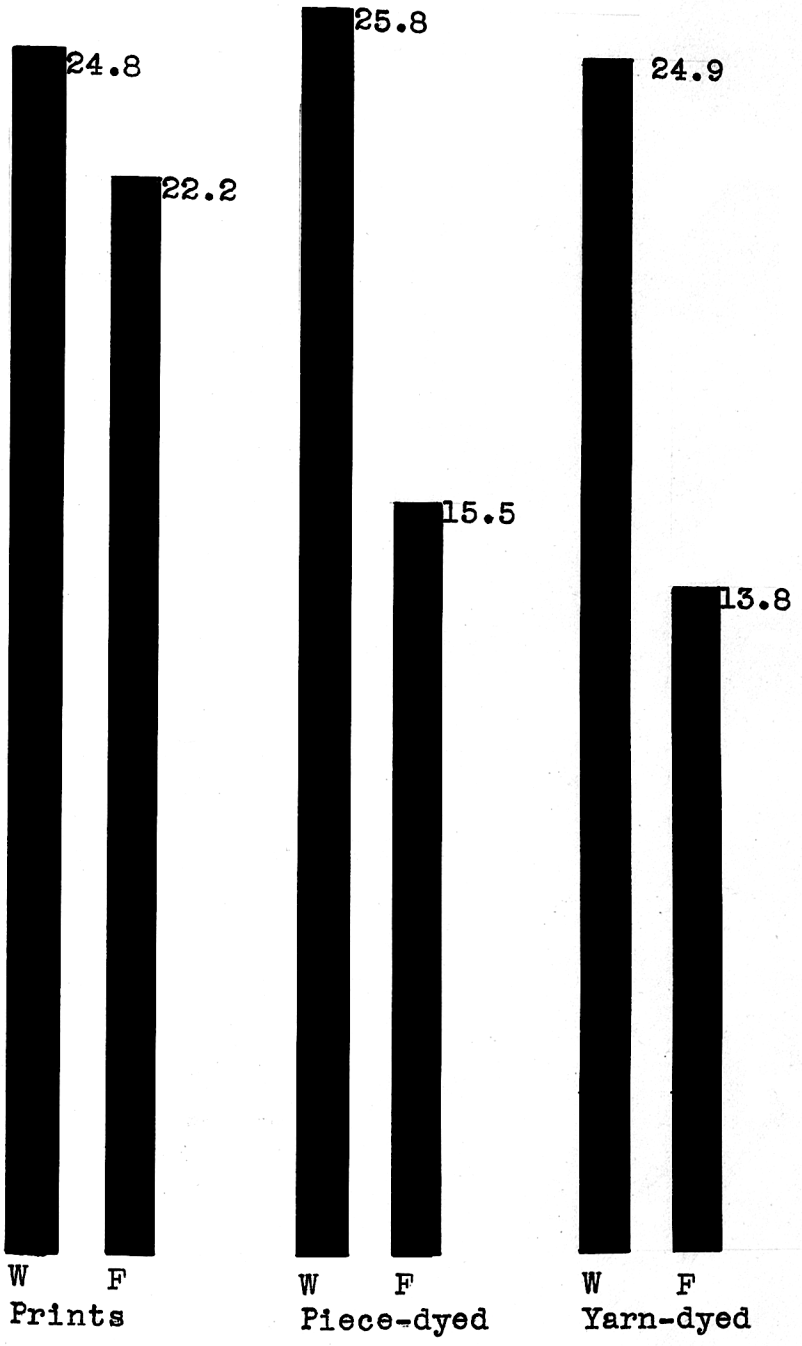


Fig. 2. Percentage of loss of tensile strength due to laundering and pleating. W, warp. F, filling.

Explanation of Fig. 3

Percentage of variation of breaking strength due to laundering and starching shows a loss in strength in the warp strips of all fabrics but little loss in the filling of the prints and a gain in strength of the filling strips of both the piece-dyed and yarn-dyed fabrics.

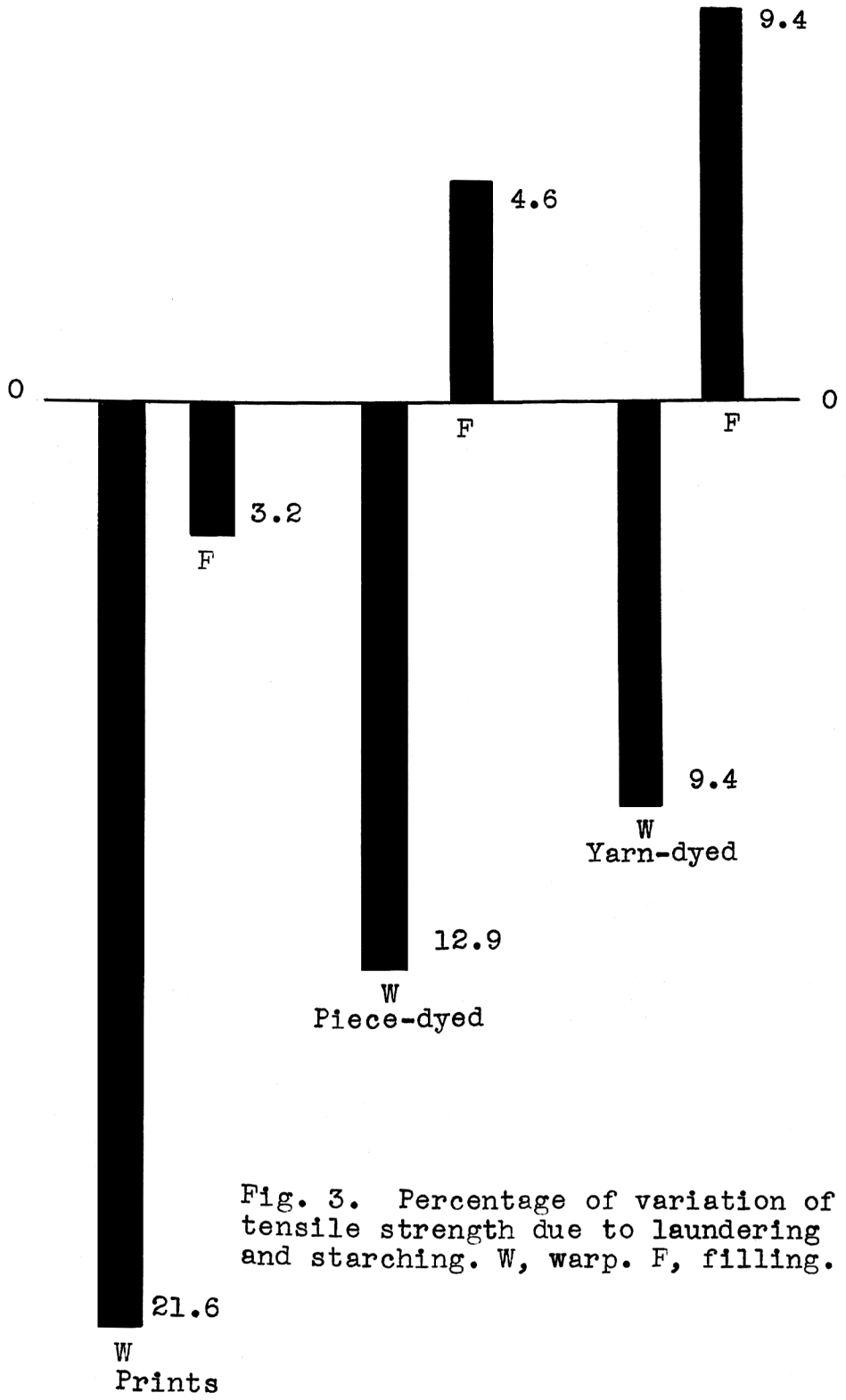


Fig. 3. Percentage of variation of tensile strength due to laundering and starching. W, warp. F, filling.

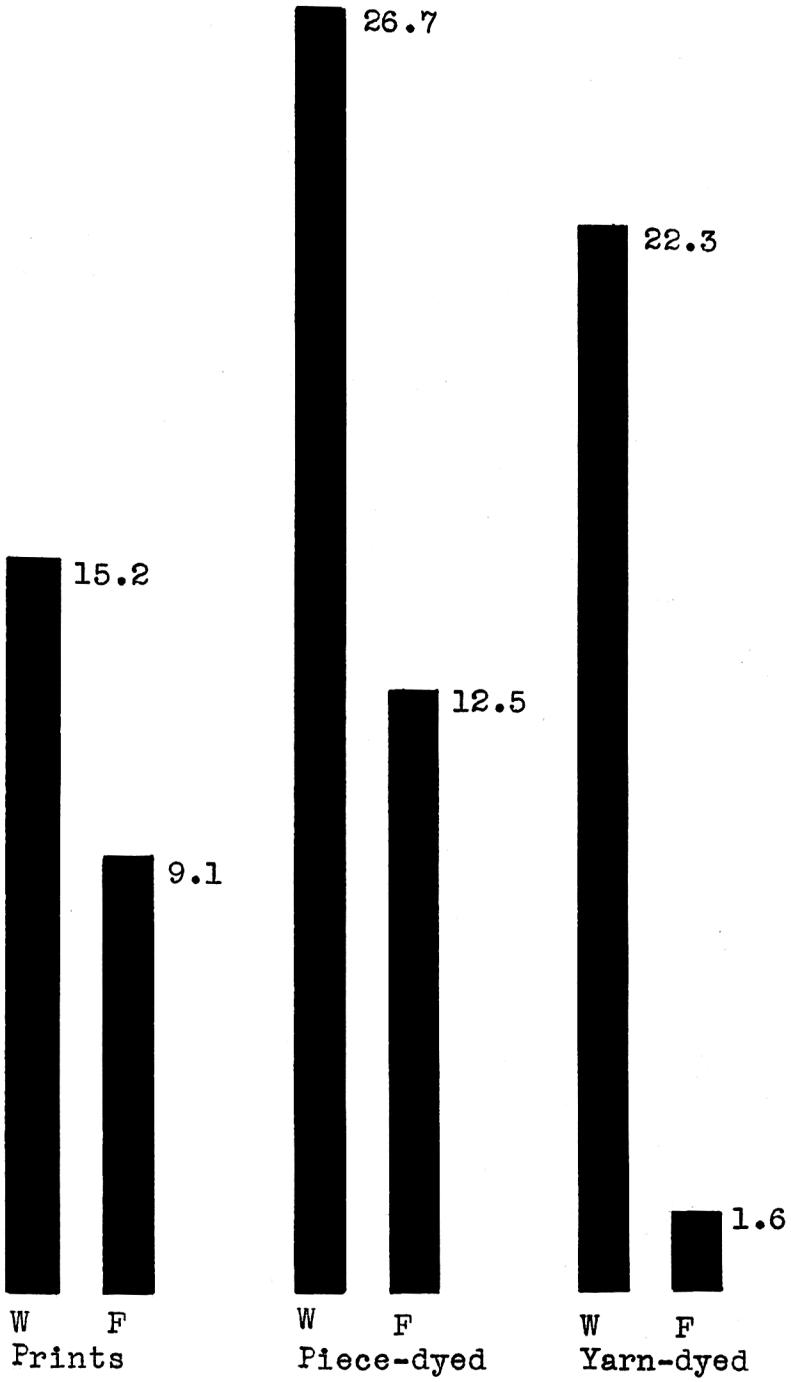


Fig. 4. Percentage of loss of tensile strength due to laundering, starching, and pleating. W, warp. F, filling.

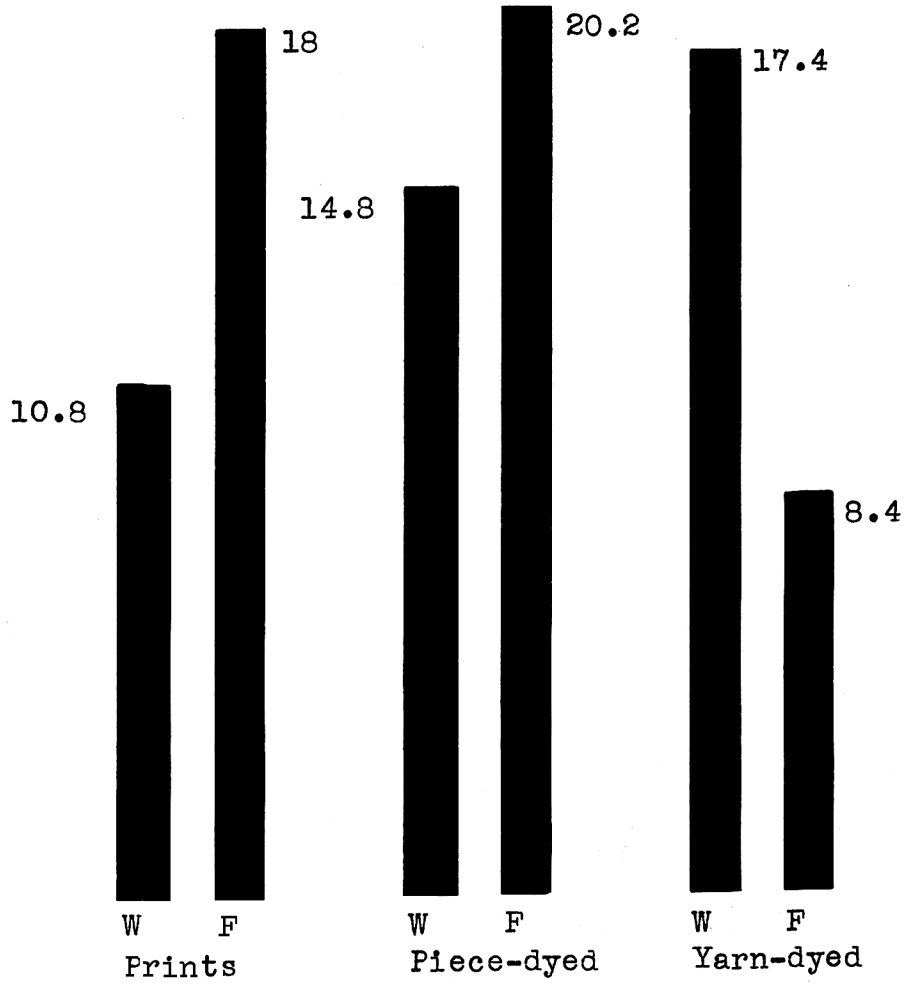


Fig. 5. Percentage of loss of tensile strength due to sunlight. W, warp. F, filling.

Table 5. Elongation of 12 fabrics tested, expressed in percentage, warpwise and fillingwise, after subjection to various treatments.

Specimen	Control		Laundered plain								Laundered pleated								Exposed to sunlight			
			No starch		Percent variation from control		Starched		Percent variation from control		No starch		Percent variation from control		Starched		Percent variation from control				Percent variation from control	
	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling	warp	filling
Prints																						
1	4.5	12.8	7.5	12.7	+3.0	-0.1	10.6	18.5	+ 6.1	+ 5.7	8.0	16.0	+3.5	+3.2	11.0	10.8	+ 6.5	- 2.0	5.0	13.0	+0.5	+0.2
2	6.0	9.7	7.6	12.5	+0.4	-2.8	11.8	13.0	+ 5.8	+ 3.4	8.8	13.1	+2.2	+3.4	12.8	19.0	+ 6.8	+ 9.3	5.0	10.0	-1.0	+0.3
3	8.3	15.3	9.0	11.7	+0.7	-3.6	11.0	17.6	+ 2.7	+ 2.3	7.6	12.8	-0.7	-2.5	12.0	20.1	+ 3.7	+ 4.8	4.4	12.0	-3.9	-3.3
4	5.0	14.2	9.8	12.6	+3.2	-1.6	8.6	17.0	+ 3.6	+ 2.9	6.5	14.0	+1.5	-0.2	10.6	18.3	+ 5.6	+ 4.1	2.0	13.0	-3.0	-1.2
Average	5.7	13.0	8.47	12.4	+2.77	-0.6	10.5	16.5	+ 4.8	+ 3.5	7.72	13.97	+2.1	+0.97	11.6	17.05	+ 5.9	+ 4.05	4.1	12.0	-1.6	-1.0
Piece-dyed																						
5	3.5	11.8	10.0	11.2	+6.5	-0.6	9.6	15.0	+ 6.1	+ 3.8	11.0	14.8	+7.5	+3.0	12.5	19.7	+ 9.0	+ 7.9	5.3	1.29	+1.8	+1.1
6	7.5	14.5	10.8	14.0	+3.3	-0.5	11.8	18.0	+ 4.3	+ 3.5	8.3	14.0	+0.8	-0.5	14.0	17.0	+ 6.5	+ 2.5	5.0	10.0	-2.5	-4.5
7	4.7	10.3	12.2	14.0	+7.5	+3.7	15.0	31.0	+10.3	+20.7	6.5	13.0	+1.8	+2.7	7.8	17.1	+ 3.1	+ 6.8	4.6	11.0	-0.1	-0.7
8	4.8	7.5	6.3	11.7	+1.5	+4.2	8.0	17.1	+ 3.2	+ 9.6	9.6	15.0	+4.8	+7.5	11.5	23.0	+ 6.7	+15.5	4.0	8.0	-0.8	+0.5
Average	4.9	11.0	9.82	12.7	+4.92	+1.7	11.1	20.3	+ 6.2	+ 9.3	8.85	14.2	+3.95	+3.2	11.45	19.2	+ 6.55	+ 8.2	4.7	10.47	-0.2	-0.53
Yarn-dyed																						
9	8.7	8.3	11.5	11.1	+2.8	+2.8	17.0	13.0	+ 8.3	+ 4.7	12.5	9.5	+3.8	+1.2	17.1	11.3	+ 8.4	+ 3.0	8.0	7.5	-0.7	-0.8
10	8.2	8.2	12.4	9.4	+4.2	+1.2	18.0	14.0	+ 9.8	+ 5.8	12.3	11.0	+4.1	+2.8	18.6	16.5	+10.4	+ 8.3	9.0	7.0	+0.8	-1.2
11	8.7	7.3	7.0	8.6	-1.7	+1.3	18.0	16.0	+ 9.3	+ 8.7	14.5	10.5	+5.8	+3.2	19.1	14.5	+10.4	+ 7.2	6.8	7.5	-1.9	+0.2
12	8.3	9.0	12.2	8.0	+3.9	-1.0	15.0	13.0	+ 6.7	+ 4.0	12.1	8.1	+3.8	-0.9	19.3	12.3	+11.0	+ 3.3	7.6	6.6	-0.7	-2.4
Average	8.5	8.2	10.8	9.02	+2.3	+0.82	17.0	14.0	+ 8.5	+ 5.8	12.85	9.8	+4.35	+1.6	18.5	13.65	+10.0	+ 5.46	7.82	7.15	-0.68	-1.05

fillingwise. Warpwise, the piece-dyed averaged 14.8 percent loss and fillingwise 20.1 percent. The breaking strength of the yarn-dyed was lowered 17.4 percent warpwise and 8.4 percent fillingwise after exposure to sunlight for 120 hours.

Elongation as well as breaking strength is considered a factor in the service qualities of cloth. The elongation of the yarn-dyed fabrics was practically the same warpwise and fillingwise. In the prints and piece-dyed fabrics, the elongation was uneven, being low warpwise and high fillingwise (Table 5).

Sunlight was the greatest factor in producing fading. Laundering caused some fading in these fabrics which were purchased as color fast. The ginghams (yarn-dyed) were most nearly color fast. Only one gingham (blue check) faded noticeably in laundering (Table 7); and only one (yellow check) faded noticeably in sunlight (Table 8). None of the yarn-dyed faded when exposed to room light (Table 6). The piece-dyed, in general, showed more fading in sunlight than either of the other groups (Table 9). The proportion of fading in the piece-dyed and in the prints, due to laundering, was about equal. No one color could be said to be more fast than any other.

Table 6. Comparison of fading qualities of 12 fabrics after 3 months' exposure to room light.

Specimen	Number of persons arranging each specimen in group: Not noticeable	Slight	Pronounced	Undesirable
		Prints		
1	10	10	0	0
2	16	4	0	0
3	16	4	0	0
4	18	2	0	0
		Piece-dyed		
5	20	0	0	0
6	20	0	0	0
7	20	0	0	0
8	18	2	0	0
		Yarn-dyed		
9	18	2	0	0
10	18	2	0	0
11	20	0	0	0
12	20	0	0	0

Table 7. Comparison of fading qualities of 12 fabrics after 20 launderings.

Specimen	Number of persons arranging each specimen in group: Not noticeable	Slight	Pronounced	Undesirable
		Prints		
1	12	8	0	0
2	18	2	0	0
3	4	16	0	0
4	14	6	0	0
		Piece-dyed		
5	14	6	0	0
6	8	12	0	0
7	10	10	0	0
8	14	6	0	0
		Yarn-dyed		
9	15	5	0	0
10	16	4	0	0
11	0	18	2	0
12	12	8	0	0

Table 8. Comparison of fading qualities of 12 fabrics tested after 120 hours' exposure to direct sunlight.

Specimen	Number of persons arranging each specimen in group: Not noticeable	Slight	Pronounced	Undesirable
		Prints		
1	0	0	2	18
2	0	8	12	0
3	0	6	14	0
4	0	0	16	4
		Piece-dyed		
5	0	0	0	20
6	0	0	10	10
7	0	0	16	8
8	0	2	16	2
		Yarn-dyed		
9	10	10	0	0
10	12	8	0	0
11	14	6	0	0
12	0	8	12	0

Table 9. Summary of fading qualities of three groups of fabrics tested due to various factors.

Treatment	Fabric group	Number of times 20 people placed fabrics in each color change rating: Rating of color changes: Not noticeable	Slight	Pronounced	Undesirable
Exposure to sunlight	Prints	0	14	44	22
	Piece-dyed	0	2	46	40
	Yarn-dyed	0	32	12	0
Laundering	Prints	48	32	0	0
	Piece-dyed	46	34	0	0
	Yarn-dyed	43	35	2	0
Exposure to room light	Prints	60	20	0	0
	Piece-dyed	78	2	0	0
	Yarn-dyed	76	4	0	0

CONCLUSIONS

The number of fabrics tested was not extensive enough to draw final conclusions but the findings of this study indicate that:

1. Fastness of color is the only service quality which is affected by the method of applying color.

2. Breaking strength is not dependent upon thread count.

3. Neither starching nor pleating weakens fabrics noticeably.

4. Sunlight is a greater factor in fading than laundering or exposure to room light.

5. Laundering is a greater factor in deterioration of strength than sunlight.

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