THE PHYSICAL PROPERTIES AND WASH-AND-WEAR PERFORMANCE OF VIYELLA, A WOOL AND COTTON BLEND FABRIC

A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TEXTILES AND CLOTHING IN THE GRADUATE SCHOOL OF THE TEXAS WOMAN'S UNIVERSITY

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We hereby recommend that the thesis prepared under our supervision by Sally Crisler Lowe

entitled The Physical Properties and Wash-and-Wear Performance of Vivella, A Wool and Cotton Blend Fabric

be accepted as fulfilling this part of the requirements for the Degree of Master of Science in Textiles and Clothing

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CHAPTER I

INTRODUCTION

There is no perfect fiber. Each one has good, fair, and poor characteristics. However, when two compatible fibers are blended together the best qualities are emphasized and the poor qualities minimized.

Blends are not new, but in the past 20 years they have become very important. Viyella, a trademark for a lightweight British twill fabric, 55 percent wool and 45 percent cotton, is one of the oldest blends. The fibers in the yarn are blended before spinning; the weave is usually a 2-up, 2-down twill (7). Hollen and Saddler state, "It feels like a lightweight wool but does not felt and is washable" (6). "The fabric is made in qualities and weights suitable for many purposes, including shirts, pajamas, underwear, and dresses" (8).

According to Adkins (11) of Wallstreet Custom Clothiers in Oklahoma City, Viyella has been used in shirts for over three years at his business establishments located in major cities throughout the midwest. However, Adkins stated that all his tailored shirts are manufactured in Hong Kong where the Viyella is purchased duty-free from Scotland, and then

imported into the United States as the finished product. Adkins feels his customers like the Viyella because it has the "durability of Pendleton wool, yet the softness of flannel." The western shirt is the most popular style made from Viyella at the majority of Adkins' franchises. Although the care label reads "machine washable," Adkins recommends dry cleaning for the Viyella shirts, which retail for $80.00 each.

The 55/45 wool and cotton blend also has been found at a limited number of exclusive fabric stores throughout the United States. Plaids, prints and solids are available in a variety of colors. The retail price of almost $20.00 a yard constitutes the fact that it is scarce in this country.

Justification for Study

There is very little research data concerning Viyella's wash-and-wear performance to substantiate its wide acclaim as being an excellent washable wool fabric. This fabric has been woven in England since November 23, 1893, by William Hollins and Company Limited, Derby, England. This momentous day marked a clothing revolution 109 years after the Company had been formed (12).

Just three years earlier, in 1890, William Hollins had bought a factory in the Via Gellia, near Matlock Bath in

Derbyshire, England. The local inhabitants called the valley the "Vi Jella," and from this came the name of the cloth. Viyella is the first trademark for a piece of fabric (13).

For years, William Hollins had been spinning yarn from a blend of the two finest fibers of their kind--Merino wool, famed for its soft "handle" and lightness, and long-staple cotton, unrivalled for sheer luxury and outstanding wear. However, until 1893 no one had been able to weave these fibers into a cloth which would afford the wearer all the benefits of these unique properties (12).

As Viyella is a blend of natural fibers the care is of great importance. The William Hollins Company recommends "washing in warm soapy water, squeezing gently several times, and avoiding harsh treatment; rinsing in hand-warm water and allowing to dry naturally, away from intense heat; pressing with a medium hot iron while still a little damp and hanging to air" (14). However, care labels on the bolts of Viyella fabrics read "do not dry clean, do not use dryer, do not iron; machine wash-warm water, air dry."

With the ever-increasing returns of natural fibers used in ready-to-wear and home-sewing, an investigation of the physical properties and performance of this unusual blend was considered necessary. Not only are the "machine

washable" and "easy care" developments pushing natural fibers into competition with other fibers, but there is also the demand by the average consumer for more economical ways in which to care for their garments. The following study was designed for this purpose.

Statement of Problem

The purpose of this study was to investigate the physical properties and wash-and-wear performance of Viyella, a wool and cotton blend fabric, during home-type laundering periods.

Objectives of Study

The overall objective of the study was to determine the physical properties and the wash-and-wear performance of Viyella, a 55/45 wool-cotton intimate blend, at specific periods during home laundering procedures.

Specific objectives were as follows:

1. To determine the following physical properties of the fibers and fabrics before laundering:
   a. fiber content
   b. yarn count
   c. fabric weight

d. weave pattern

e. yarn structure

2. To evaluate the fabrics periodically through 25 laundering periods by means of the following tests:

   a. breaking strength

   b. tearing strength

   c. pilling resistance

   d. colorfastness to laundering

   e. dimensional stability

   f. durable press appearance

3. To ascertain the whiteness retention of the white fabric.

4. To determine whether the care labels of the Viyella fabric as recommended by the manufacturer are valid.

Delimitations

This study was limited solely to the examination of five different colors of Viyella fabrics, each of the same weave structure, and of a comparable weight. The laundering periods were limited to a maximum of 25.

CHAPTER II

REVIEW OF LITERATURE

Previous research performed on wool and cotton blends has been primarily concerned with blend levels of a consistently higher cotton content.

In 1976, researchers at the Textile Utilization Research Laboratories of Texas Woman's University conducted a wear-study with skirts made from a 50/50 wool and cotton blend. The purpose of the research was to compare the performance of two types of durable press finishes on the wool-cotton blend with regard to appearance and durability through wear and laundering. Results of the analysis showed that the conventional durable press finish provided the skirts with the smoothest appearance. The Press 10.11 finish fell next in line, and the untreated skirts displayed the poorest appearance. Additional findings showed that repeated wear-laundering periods were not harmful to the appearance of the skirts (5).

The performance of machine washable and durable press fabrics of wool and wool blends was also evaluated in the research done by Greenhaw (10). Fourteen experimental fabrics were evaluated for wash-and-wear appearance,

dimensional stability, air permeability, and colorfastness. Only the machine washable fabrics were analyzed for pilling resistance, breaking strength, resistance to flat abrasion and resistance to flexing and abrasion. Crease retention was evaluated on the durable press fabrics. A review of the data revealed that neither fiber content nor washing temperature had any significant effect upon the wash-and-wear appearance of the machine washable fabrics. However, the durable press fabrics were found to be superior in comparison to that of the machine washable fabrics in wash-and-wear appearance, dimensional stability and colorfastness, whereas the machine washable fabrics were more air permeable than the durable press fabrics.

Texas Technological University in Lubbock, Texas has performed extensive research on cotton and wool blend fabrics over the past several years. Mehta (2), in 1973, investigated the wet fixation of resins in cotton-wool blend fabrics by using steam in an attempt to obtain durable press fabrics with good abrasion resistance. The fabrics used were desized, plain weave, prepared from intimate fiber blends of (a) 50 percent cotton/50 percent shrinkproof wool and (b) 50 percent cotton/50 percent untreated wool. These blends were treated with melamine formaldehyde resin and/or a crosslinking agent by the pad/dry/cure process and wet

fixation techniques utilizing steam. Wet fixation techniques produced durable press fabrics with improved flex abrasion resistance over the pad/dry/cure treatment. Compared to the cotton-untreated wool blend fabric, the cotton-shrinkproof wool blend fabric retained better strength properties after durable press treatment. Mehta (3), also studied the effect of pH of the tetrakis (hydroxymethyl) phosphonium chloride (THPC)--methylated trimethylomelamine-urea formulation in attempts to improve dimensional stability and easy-care properties accompanied with durable flame-resistance of cotton-wool blends. The pH of the formulation, adjusted from 5.0 to 9.0, was studied on percentages of 70/30 and 50/50 cotton-wool blend woven fabrics. Results presented in the investigation have shown that optimum performance of flame-resistance and the retention of physical properties have occurred with treatment at pH 6 of the pad-bath. For example, on application of THPC formulation at pH 6 both 70/30 and 50/50 cotton-wool blend fabrics survived 50 washings, exhibited good shrinkage control and retained 81-91 percent breaking strength.

O'Connell, Pardo and Fong (4), studied the application of dimethylol dehydroxyethy-leneurea to cotton-wool blend fabrics, after stabilizing the wool fibers against felting shrinkage, to prepare the fabrics for durable press finishes.

They obtained fabrics with high durable press ratings but with almost 90 percent loss in flex abrasion resistance.

Anerud (9) researched the development of dye formation for blends of wool and cotton to achieve the 1975 fashion colors for her Master's Thesis at Texas Woman's University. In 1978, Lupton (1), of Texas Tech University compiled information regarding the methods of preparing, dyeing, and finishing cotton and wool blend fabrics. Most of this information is a composite of letters and reports written during 1973 to and for companies interested in the subject of handling cotton-wool blends.

Other studies on wool and cotton blends have been conducted and are underway at the present time, but few findings have been published to date concerning the performance of Viyella, or any wool-cotton blend with a wool content higher than 50 percent.

CHAPTER III

PLAN OF PROCEDURE

This research was conducted using five pieces of Viyella fabric acquired from Richard Brooks of Dallas. Each was subjected to initial testing before laundering, as well as, testing at predetermined periods throughout 25 launderings.

Fabric Types

Five pieces of Viyella, a 55 percent wool and 45 percent cotton blend, of five different colors were used as experimental fabrics. There were approximately 3½ yards of each of the five colors. See Table 1 and Figure 1 for an outline of the construction characteristics and samples of each of the experimental fabrics.

Laundering Procedure

Laundering was accomplished as recommended in washing condition I (105° F) of AATCC Test Method 143-1975 (15e). The four dark-colored blends were laundered together at the designated temperature. The white piece of fabric was laundered separately at the same temperature to avoid

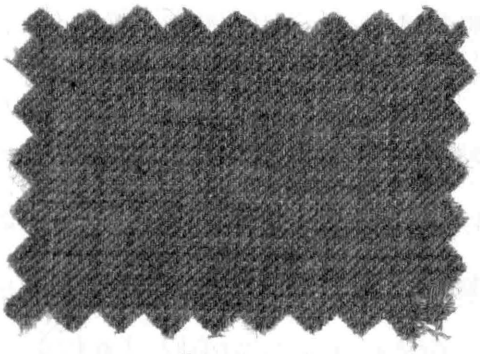
TABLE 1

FABRIC CONSTRUCTION DETAIL

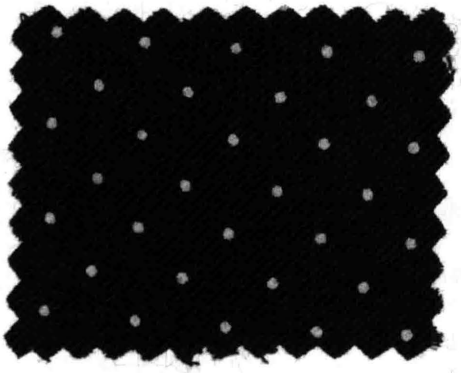
	Fabric	Fiber Content	Initial Yarn Count		Weight per Square Yard (Ounces)	Weave
			Warp	Filling		
1.	Dark Grey	55/45 Wool-Cotton	54.4	53.0	3.81	Twill*
2.	Light Grey	55/45 Wool-Cotton	53.4	52.8	3.84	Twill*
3.	Maroon	55/45 Wool-Cotton	54.8	55.2	4.12	Twill*
4.	Plaid	55/45 Wool-Cotton	54.8	53.4	3.82	Twill*
5.	White	55/45 Wool-Cotton	54.4	55.2	3.95	Twill*

*Right-hand twill: 2-up, 2-down.

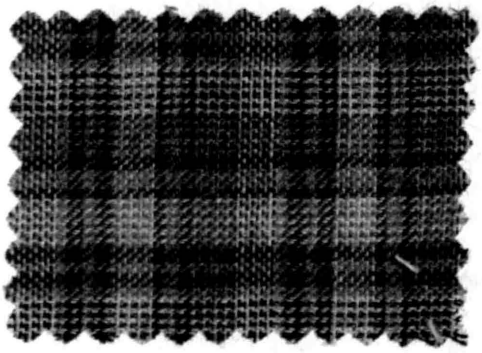
1. Dark Grey



2. Light Grey



3. Maroon



4. Plaid

5. White

Fig. 1. Samples of the five experimental fabrics.

possible discoloring of the white fabric. All laundering was done in four-pound loads using 90 grams of the AATCC 124 laundry detergent. Rinsing was in cold water.

The fabrics were removed immediately upon completion of the wash and rinse cycles, and hung over a clothes line in the warp direction where they air-dried. After drying was completed, the fabrics were marked indicating wash period. The procedure was repeated until 25 laundering intervals were completed.

Equipment

A domestic Whirlpool LDA 9800 washer equipped with a #600 Kenmore agitator as specified in AATCC Test Method 124-1975 (15b) was the washer used for all laundering. The design of this machine includes an extra large 2.71 cubic foot washing drum, two washing agitator speeds, and two spin speeds. The rinse consists of a power spray rinse and an agitated deep rinse.

A Sears hand steam iron was used for touch-up ironing before the fabrics were evaluated for dimensional stability. The setting was #3 Permanent Press. A piece of white paper was placed between fabric and iron to avoid possible heat damage to the fibers but allow an accurate reading of the shrinkage loss.

Fabric Evaluations

During the course of the study the experimental fabrics were evaluated with regard to their physical properties and wash-and-wear performances at intervals of 0, 1, 5, 15 and 25 laundering periods with respect to each test performed. The visual evaluations during the study included durable press appearance, pilling resistance, colorfastness, whiteness retention and dimensional stability.

Destructive tests were applied to the experimental fabrics initially and after 5, 15 and 25 laundering periods. The tests included breaking strength and tearing strength. All specimens before being tested were placed in standard conditions specific to the test being conducted.

Fiber Content

Each experimental fabric was evaluated for fiber content according to the ASTM Designation: D-276-80 and AATCC Test Method 20-1977 (15a).

Twenty percent hydrochloric acid and 95 percent sulfuric acid were used in the solubility tests. Small samples of each of the experimental fabrics were immersed in the 20 percent hydrochloric acid and allowed to remain for 20 minutes. The fibers were removed and examined under the microscope. The same fibers were placed in a solution

of 95 percent sulfuric acid. After 20 minutes all fibers were observed to be completely dissolved.

Three 3-inch squares from each experimental fabric were evaluated for burning characteristics. After igniting the fabric, an odor of burning feathers was observed, extinguishment took place in approximately 26 seconds, and a crisp, dry, black ash remained.

Yarn Count

Each experimental fabric was analyzed for yarn count initially in accordance with the method outlined in ASTM Designation: 1910-75 (16b).

One inch counts were taken at five different places on each fabric both in the warp and the filling directions. The Alfred Suter Pick Counter was used for this procedure. No count was taken less than five inches from the selvage.

Fabric Weight

The initial weight of each fabric was determined in accordance with ASTM Designation: 1910-75 (16b).

Three 6-inch squares from each fabric were conditioned overnight to establish moisture equilibrium. The samples were weighed separately on a Mettler analytical balance to the nearest 0.01 percent of their weight. Weights were

averaged and the following formula was used to determine the weight of each fabric in ounces per square yard:

$$\text{Weight, ounces per Square Yard} = \frac{\text{Average Weight of Specimens in grams}}{\text{Total Area of Specimen in Square Inches}} \times 45.72$$

Breaking Strength

The experimental fabrics were tested for dry breaking strength following ASTM Designation: D 1682-75 on the Grab Method (16c).

Five warp and five filling specimens which measured four inches wide and six inches long were cut on the straight grain. Each specimen was cut in such a way that no two contained identical yarns in either direction. The fabrics tested initially and after 5, 15 and 25 laundering periods, were conditioned overnight or for a minimum of eight hours at a standard temperature of 70° ± 2° F and a relative humidity of 65 ± 2 percent. The Instron Tensile Tester was used to measure the pounds required to break the specimens, and the results were recorded for each specimen of each fabric to the nearest 0.1 pound. Strengths are reported as averages of the five specimens.

Tearing Strength

Five specimens from the warp direction and five from the filling direction were tested on the Elmendorf Tear Tester initially and after 5, 15 and 25 laundering periods. With the 3,200 gram NBS augmenting weight attachment on the tester, ASTM Designation: D 1424 (16d) was followed in determining the force in grams required to tear each specimen. Each specimen was cut parallel to the warp and filling yarns in such a way that no two specimens contained identical yarns in either direction. Prior to testing all specimens were placed in a room having standard conditions of 70° ± 2° F and 65 ± 2 percent relative humidity.

Durable Press Appearance

The durable press appearance of the experimental fabrics was determined according to the overhead lighting procedure of AATCC Test Method 124-75 (15b) after 1, 5, 15 and 25 laundering periods. After the fabrics were thoroughly dry, each fabric was placed over a clothes line with warp yarns aligned vertically, and allowed to hang for two hours before being evaluated.

The durable press appearance was rated by three panel members in a semi-darkened room with walls draped with black-out fabrics. A flourescent overhead lighting system provided the lighting for the evaluation. The fabric was

draped over a metal rod (filling yarns horizontal) attached to a viewing board below the light in a manner so that the selvage could not be seen by the panel members. The AATCC Photographic Standards for smoothness were placed on either side of the fabric. The observers independently rated each fabric, standing four feet from the viewing board; the smoothness of the fabric was compared with the standards. The three ratings were averaged to represent the durable press appearance of each fabric.

Pilling Resistance

The Random Tumble Pilling Tester was used to ascertain the pilling resistance of the experimental fabrics according to the procedure given in ASTM Designation: 1375-72 (16e). Photographic pilling standards were used in the rating procedure.

Three four-inch squares which served as specimens were cut from each of the fabrics initially and after 25 laundering periods. The sides of the squares were cut parallel to the warp and filling yarns in such a way that no two specimens contained identical yarns in either direction. The edges of the specimens were sealed to prevent raveling with Elmer's glue, and the specimens were allowed to dry for at least two hours before testing.

In preparation for testing, each pilling chamber of the tester was lined with a cork liner which was used for one hour on each side. The three squares of each fabric color were placed in a chamber with approximately 0.2 inch of a 75 gram grey cotton sliver. After 30 minutes of pilling, the specimens were removed from the test chamber and brushed to remove excess sliver and placed on a table for further evaluation. Each test specimen and the rating standard were placed at a 45° angle inside the Macbeth Spectralight cabinet which provided the correct lighting conditions for evaluation purposes. A three-member panel rated each specimen according to the following scale:

5 - No pilling

4 - Slight pilling

3 - Moderate pilling

2 - Severe pilling

1 - Very severe pilling

An average of the nine observations per fabric color was reported as the rating for each fabric.

Dimensional Stability

In order to determine the percentage of change in the dimensions of each experimental fabric, one 10-inch shrinkage square was marked in the middle of each fabric. The

square was machine stitched at each corner and at midpoints between the corners after being marked parallel to the warp and filling directions by a graduated steel ruler. Calculations of the shrinkage of each fabric were made after 1, 5, 15 and 25 laundering periods. A piece of white paper was placed over the 10-inch square area prior to pressing in order to avoid possible heat damage to the fibers, but allow accurate measurements of the shrinkage loss. The hand iron setting used was #3 Permanent Press.

The shrinkage squares were placed flat on a table, allowed to stabilize for at least two hours. Measurements in both warp and filling directions were read in accordance with ASTM Designation: D 1905 using a metal ruler and a magnifying glass (16f).

At each of the four evaluation periods three measurements were made in each direction to the nearest one-tenth inch. The percentage dimensional change for the warp and filling directions was calculated as follows on the basis of an average of the three measurements in each yarn direction.

$$\text{Percent Dimensional Change} = \frac{\text{Original Measurement} - \text{Measurement After Laundering}}{\text{Original Measurement}} \times 100$$

Colorfastness

The degree of color lost by the fabrics was evaluated after 5, 15 and 25 laundering periods. The laundered fabric was compared with a non-laundered piece of fabric of the same color. Each test fabric and the appropriate standard were placed at a 45° angle inside the Macbeth Spectralight cabinet which provided the correct lighting conditions for evaluation purposes. Color loss was judged by a three-member panel using the AATCC Gray Scale for Color Change, Test Method 61-1975 (15c). The following scale was used to determine the degree of alteration in shade and strength of the fabrics:

5 - negligible or no change

4 - slightly changed

3 - noticeably changed

2 - considerably changed

1 - much changed

When the appearance of a test specimen fell between that of two ratings, a half value was assigned; for example, 3.5, 2.5, etc.

Whiteness Retention

Only the white colored fabric was evaluated for whiteness retention initially and after 5, 15 and 25 laundering

periods. A Hunterlab Model D-40 Reflectometer for whiteness was used to determine the whiteness retention of the fabric according to AATCC Test Method 110-75 (15d). Reflectance readings were taken in five different areas of the fabric not less than two inches from the selvage.

Statistical Analysis

The type of statistical analysis used was a "factorial" repeated measures design. The factors were fabric type, warp or filling yarn direction, and the laundering intervals of 0, 5, 15, 25. The analysis of variance was used to determine where differences in the factors existed at the 0.05 level of significance.

CHAPTER IV

PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

The main objective of this study was to evaluate Viyella fabrics for selected physical properties and wash-and-wear performance. Data which resulted from evaluations of the experimental fabrics initially and at designated home laundering periods are presented and discussed in this chapter. Properties investigated included fiber content, yarn structure, fabric weave, fabric weight and fabric yarn count. Laboratory tests which were performed included breaking strength, tearing strength, durable press appearance, pilling resistance, dimensional stability, colorfastness and whiteness retention.

The data obtained from the tests were analyzed by means of a "factorial" repeated measures design. The factors were fabric type, warp or filling yarn directions, and the specific laundering period with respect to the test performed. The analysis of variance was used to determine where differences in the factors existed at the 0.05 level of significance.

Fabric Description

The experimental Viyella fabrics were found to be intimate blends of 55 percent wool and 45 percent cotton according to the results of the various tests performed on all five pieces of fabric. The spun yarn had a Z twist and single yarn structure.

The fabrics were a twill weave, 2-up and 2-down, and were representative of weights ranging from 3.8 to 4.1 ounces per square yard. The yarn counts varied only slightly from 53.4 to 54.8 yarns per inch in the warp direction, and from 52.8 to 55.2 yarns per inch in the filling direction (see Table 1 and Figure 1 in Chapter 3).

Fabric Evaluations

Breaking Strength

The breaking strength test was performed on the experimental fabrics initially and after 5, 15 and 25 laundering periods. Tables 2 through 6 and Figures 2 and 3 present the data which resulted from these tests.

The mean breaking strength values of each fabric type (Table 2) represents breaking strength average of all 10 specimens (warp and filling directions). Values ranged from 26.9 pounds initially for the dark grey fabric to 47.1 pounds after 15 launderings for the maroon fabric. A

TABLE 2

MEAN BREAKING STRENGTH VALUES OF EACH FABRIC AT DESIGNATED LAUNDERING PERIODS (POUNDS)

	Fabric	Number of Launderings			
		0	5	15	25
1.	Dark Grey	26.9	31.1	33.8	30.0
2.	Light Grey	31.8	39.1	40.5	40.0
3.	Maroon	41.7	46.6	47.1	44.3
4.	Plaid	39.6	41.0	40.0	39.2
5.	White	33.6	41.0	39.1	36.7

consistency was not found in the strength required to break the specimens from each fabric at each designated laundering period.

Table 3 and Figure 2 show the mean breaking strength values in pounds of each fabric initially and after 5, 15 and 25 laundering periods in the warp and the filling directions. In the warp direction, values ranged from 27.8 pounds initially for the dark grey fabric to 47.6 pounds after five laundering periods for the maroon fabric. The breaking strength in the filling direction ranged from 25.9 initially for the dark grey fabric to 48.2 after 15 laundering periods for the maroon fabric.

A statistical comparison of the breaking strength values of each fabric after 25 laundering periods with regard to warp and filling yarn directions is shown in Table 4. When all laundering periods were combined the maroon fabric had the highest breaking strength values both in the warp and filling directions of 44.2 and 45.6 respectively. The dark grey fabric had the lowest mean breaking strength when all laundering periods were combined with values of 30.0 in the warp direction and 30.8 in the filling direction.

The effect of laundering on the breaking strength of the warp and filling yarns for all five fabrics is shown in

TABLE 3

MEAN BREAKING STRENGTH VALUES OF EACH FABRIC AT DESIGNATED LAUNDERING PERIODS IN THE WARP AND FILLING DIRECTIONS (POUNDS)

Fabric	Number of Launderings			
	0	5	15	25
1. Dark Grey				
Warp	27.8	31.7	31.4	29.3
Filling	25.9	30.4	36.2	30.8
2. Light Grey				
Warp	32.2	39.4	40.2	37.4
Filling	31.3	38.7	40.7	42.3
3. Maroon				
Warp	40.7	47.6	46.0	42.4
Filling	42.6	45.5	48.2	46.2
4. Plaid				
Warp	40.8	39.3	37.8	36.7
Filling	38.4	42.6	42.1	41.6
5. White				
Warp	34.3	42.1	40.4	35.3
Filling	33.0	39.9	37.7	38.2

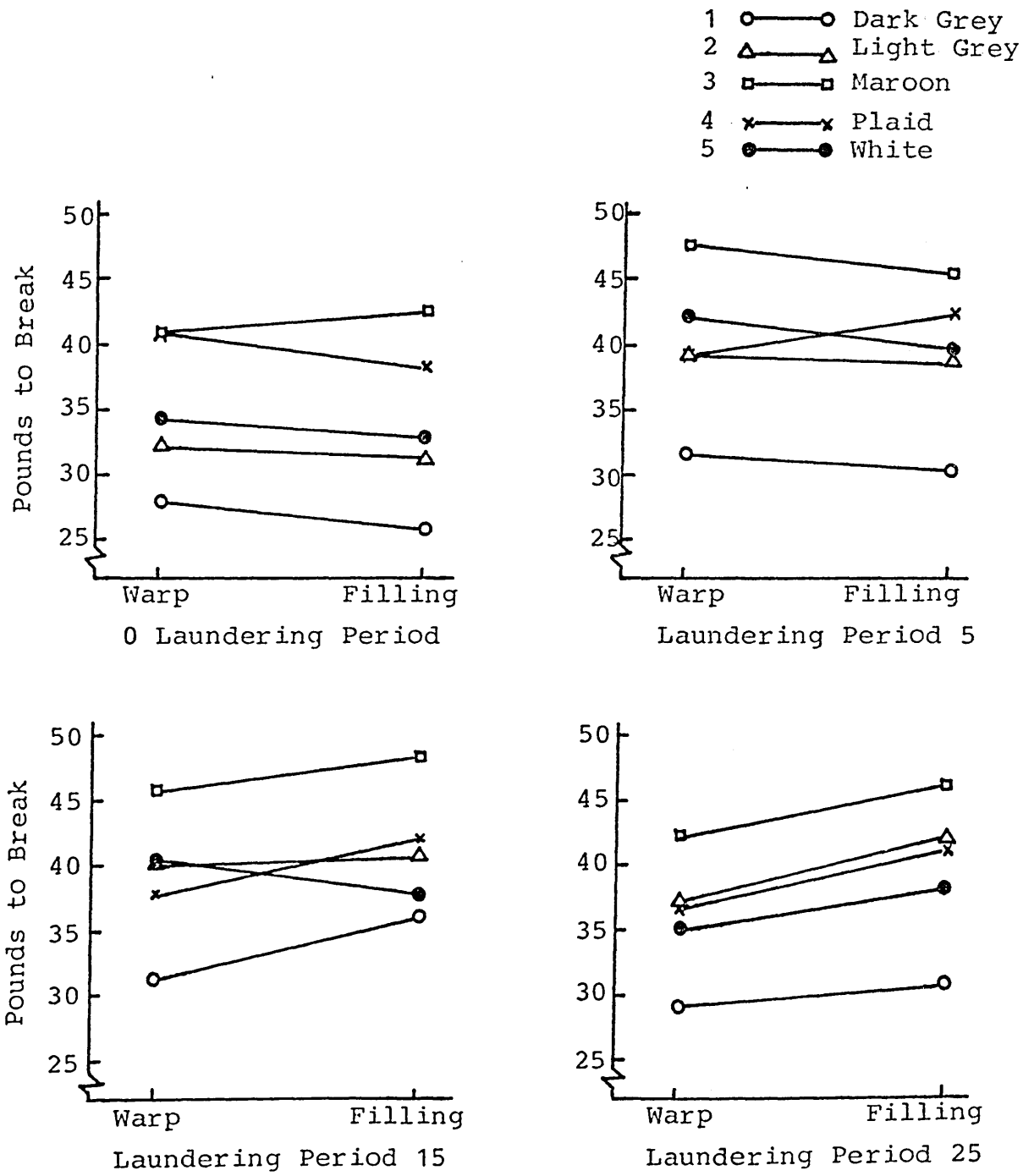


Fig. 2. Mean breaking strength values of each fabric initially and after 5, 15 and 25 laundering periods in the warp and filling directions.

TABLE 4

STATISTICAL COMPARISONS OF THE BREAKING STRENGTH VALUES OF EACH FABRIC AFTER 25 LAUNDERINGS IN THE WARP AND FILLING DIRECTIONS

Fabric	Sum of Squares	Mean*	Standard Deviation	Variance
1. Dark Grey				
Warp	600.7	30.0	2.209	4.878
Filling	616.8	30.8	4.651	21.633
2. Light Grey				
Warp	746.3	37.3	3.356	11.260
Filling	764.9	38.3	4.555	20.752
3. Maroon				
Warp	883.2	44.2	3.543	12.551
Filling	912.5	45.6	2.864	8.201
4. Plaid				
Warp	773.6	38.7	2.295	5.266
Filling	823.0	41.2	2.628	6.907
5. White				
Warp	760.3	38.0	3.605	12.997
Filling	743.9	37.2	3.181	10.116

*Pounds

Table 5 and Figure 3. The mean breaking strength values in the warp direction ranged from 35.2 pounds initially to 40.0 pounds after five laundering periods. In the filling direction the mean breaking strength values ranged from 34.2 pounds initially to 41.0 pounds after fifteen laundering periods. The fabrics, as a whole, showed better resistance to breaking in the warp direction following 5 and 15 laundering periods, whereas the fabrics showed better breaking strength properties after 15 and 25 launderings in the filling direction as depicted in Figure 3.

A three-factor analysis of variance of breaking strength values of all five fabrics indicated significant effects existed among fabric types, laundering periods and warp and filling yarn directions. Significant effects also were noted between the interaction of the fabric, laundering period and yarn direction (see Table 6).

Tearing Strength

The tearing strength tests were performed on the fabrics initially and after 5, 15 and 25 laundering periods. Tables 7 through 11 and Figures 4 and 5 present the data which resulted from these tests.

The mean tearing strength values of each fabric type (Table 7) represent combined tearing strength averages of

TABLE 5

STATISTICAL COMPARISON OF THE BREAKING STRENGTH VALUES OF ALL FABRICS AT DESIGNATED LAUNDERING PERIODS IN THE WARP AND FILLING DIRECTIONS

Laundering Period	Sum of Squares	Mean*	Standard Deviation	Variance
Initial	1,735.1	34.7	5.6189	31.5716
Warp	879.2	35.2	5.2752	27.8281
Filling	855.9	34.2	6.0148	36.1782
Five	1,986.1	39.7	5.3652	28.7858
Warp	1,000.5	40.0	5.4139	29.3108
Filling	985.6	39.4	5.4107	29.2752
Fifteen	2,003.6	40.1	5.0589	25.5923
Warp	979.1	39.2	5.1384	26.4032
Filling	1,024.5	41.0	4.9122	24.1300
Twenty-five	1,900.4	38.0	5.5429	30.7240
Warp	905.3	36.2	4.6420	21.5478
Filling	995.1	39.8	5.8703	34.4604
For Entire Population	7,625.2	38.1	5.7680	33.2694

*Pounds

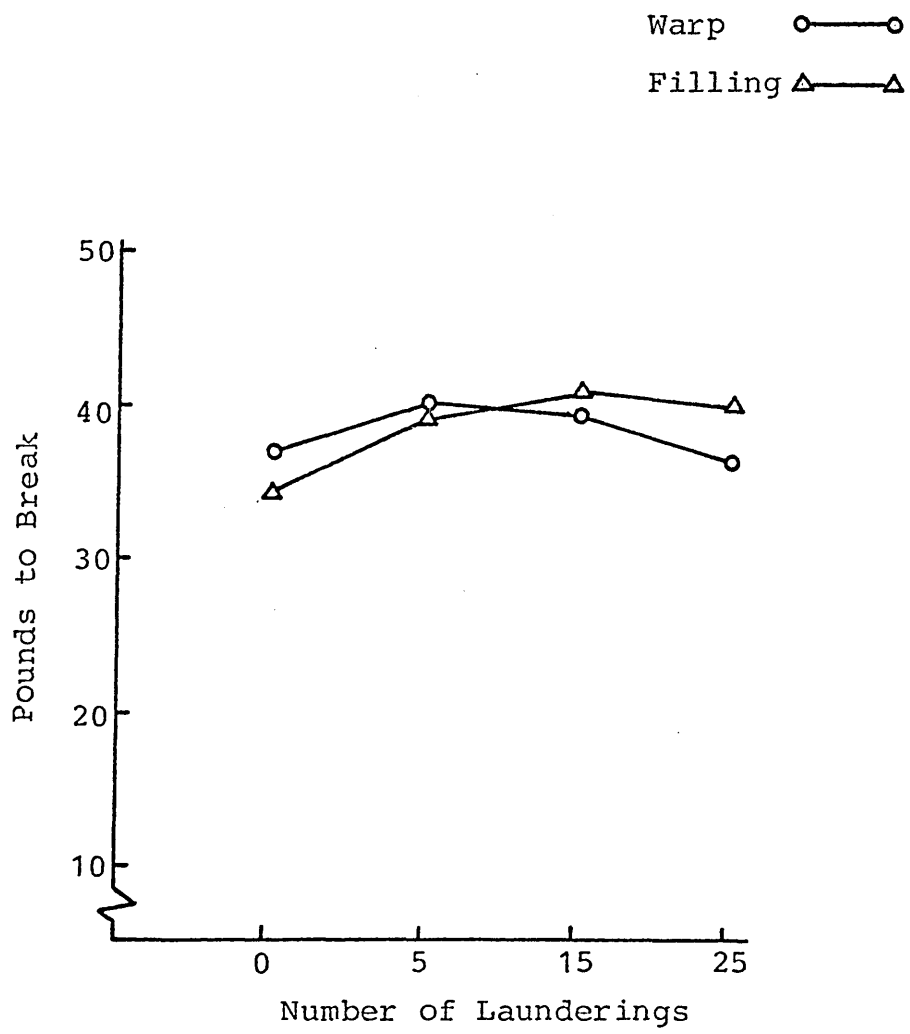


Fig. 3. Mean breaking strength values of all five fabrics initially and after 5, 15 and 25 laundering periods in the warp and filling directions.

TABLE 6

THREE-FACTOR ANALYSIS OF VARIANCE OF BREAKING STRENGTH VALUES OF ALL FABRICS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Tail Probability
Mean	290,718.37520	1	290,718.37520	73,913.96	0.0000*
Fabric	4,339.60931	4	1,084.90233	275.83	0.0000*
Laundering Period	903.59160	3	301.19720	76.58	0.0000*
Warp-Filling Direction	47.04500	1	47.04500	11.96	0.0007*
Fabric, Laundering	340.72191	12	28.39349	7.22	0.0000*
Fabric, Warp-Filling	57.27950	4	14.31987	3.64	0.0072*
Laundering, Warp-Filling	170.75700	3	56.91900	14.47	0.0000*
Fabric, Laundering, Warp-Filling	132.28850	12	11.02404	2.80	0.0017*
Error	629.31200	160	3.93320		

*Indicates significance at $\alpha = 0.05$ level.

TABLE 7

MEAN TEARING STRENGTH VALUES OF EACH FABRIC AT DESIGNATED LAUNDERING PERIODS (POUNDS)

Fabric	Number of Launderings			
	0	5	15	25
1. Dark Grey	2.6	1.9	1.8	1.8
2. Light Grey	3.8	3.0	2.5	2.5
3. Maroon	3.7	2.5	2.0	2.4
4. Plaid	2.8	2.2	1.9	1.8
5. White	3.2	2.7	2.1	2.1

the warp and filling directions. Values ranged from 3.8 pounds initially for the light grey fabric to 1.8 pounds after 25 laundering periods for the dark grey fabric and plaid fabric. All five fabrics became less resistant to tearing as laundering periods increased with stabilization occurring after 15 laundering periods. However, a consistency was not found in the strength required to tear the specimens of each fabric at each designated laundering period.

Table 8 and Figure 4 show the mean tearing strength values in pounds of each fabric initially and after 5, 15 and 25 laundering periods in the warp and the filling directions. In the warp direction, values ranged from 3.8 pounds initially for the light grey fabric to 1.8 pounds after 25 laundering periods for both the dark grey fabric and plaid fabric. The tearing strength in the filling direction ranged from 3.6 pounds initially for the light grey fabric and maroon fabric to 1.7 pounds after five laundering periods for the dark grey fabric. The maroon fabric showed a slight increase in tearing strength after 25 laundering periods in both the warp and filling directions, when compared with 15 launderings.

A statistical comparison of the tearing strength values of each fabric after 25 laundering periods with

TABLE 8

MEAN TEARING STRENGTH VALUES OF EACH FABRIC AT DESIGNATED LAUNDERING PERIODS IN THE WARP AND FILLING DIRECTIONS (POUNDS)

Fabric	Number of Launderings			
	0	5	15	25
1. Dark Grey				
Warp	2.9	2.0	1.8	1.8
Filling	2.4	1.7	1.8	1.8
2. Light Grey				
Warp	3.8	3.0	2.4	2.4
Filling	3.6	3.0	2.5	2.5
3. Maroon				
Warp	3.7	2.6	2.1	2.5
Filling	3.6	2.3	1.9	2.3
4. Plaid				
Warp	2.9	2.2	2.0	1.8
Filling	2.6	2.1	1.9	1.8
5. White				
Warp	3.3	2.9	2.3	2.1
Filling	3.1	2.5	1.9	2.2

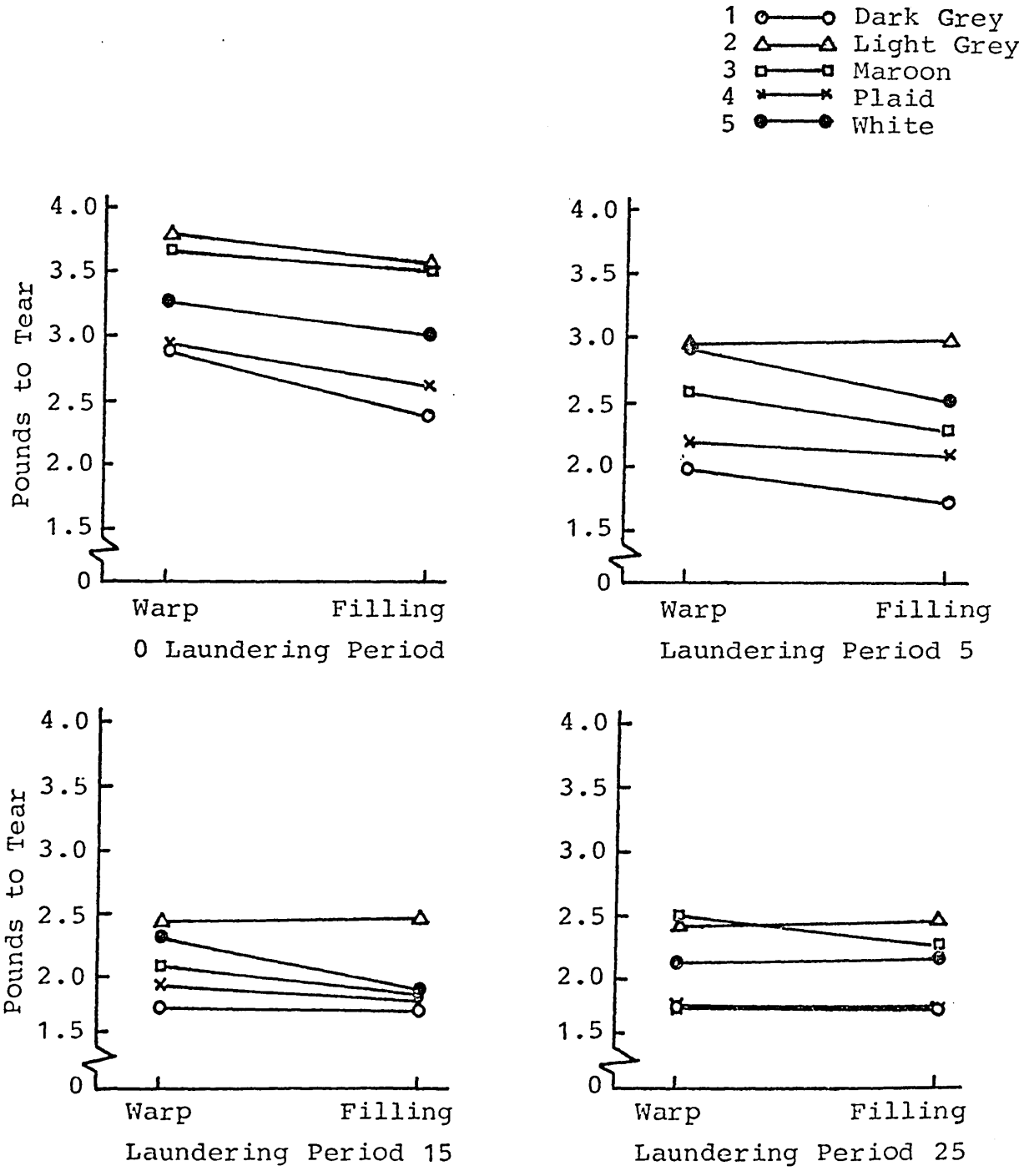


Fig. 4. Mean tearing strength values of each fabric initially and after 5, 15 and 25 laundering periods in the warp and filling directions.

regard to warp and filling directions is shown in Table 9. When all laundering periods were combined the light grey fabric had the highest tearing strength values (2.9) both in the warp and filling directions. The dark grey fabric had the lowest mean tearing strength when all laundering periods were combined with values of 2.1 pounds in the warp direction and 1.9 pounds in the filling direction.

The effect of laundering on the tearing strength of the warp and filling yarns for all five fabrics is shown in Table 10 and Figure 5. The mean tearing strength values in the warp direction ranged from 3.3 pounds initially to 2.1 pounds after 25 laundering periods. In the filling direction the mean tearing strength values ranged from 3.1 pounds initially to 2.0 pounds after 15 laundering periods. The fabrics, as a whole, showed better resistance to tearing in both the warp and filling directions initially and became less resistant to tearing as laundering periods increased. Figure 5 depicts the behavior of all five fabrics initially and after 5, 15 and 25 laundering periods.

A three-factor analysis of variance of tearing strength values of all five fabrics indicated significant effects existed among fabric types, laundering periods and warp and filling yarn directions. Significant effects also were

TABLE 9

STATISTICAL COMPARISONS OF THE TEARING STRENGTH VALUES OF EACH FABRIC AFTER 25 LAUNDERINGS IN THE WARP AND FILLING DIRECTIONS

Fabric	Sum of Squares	Mean*	Standard Deviation	Variance
1. Dark Grey				
Warp	42.2	2.1	0.476	0.226
Filling	38.2	2.0	0.306	0.094
2. Light Grey				
Warp	58.3	2.9	0.580	0.336
Filling	57.9	2.9	0.482	0.232
3. Maroon				
Warp	54.5	2.7	0.602	0.362
Filling	50.4	2.5	0.691	0.478
4. Plaid				
Warp	44.6	2.2	0.459	0.211
Filling	42.1	2.1	0.386	0.149
5. White				
Warp	53.4	2.7	0.484	0.234
Filling	48.3	2.4	0.455	0.207

*Pounds

TABLE 10

STATISTICAL COMPARISONS OF THE TEARING STRENGTH VALUES OF ALL FABRICS AT DESIGNATED LAUNDERING PERIODS IN THE WARP AND FILLING DIRECTIONS

Laundering Period	Sum of Squares	Mean*	Standard Deviation	Variance
Initial	159.3	3.2	0.4840	0.2343
Warp	82.9	3.3	0.3934	0.1547
Filling	76.4	3.1	0.5370	0.2884
Five	122.3	2.5	0.4404	0.1940
Warp	63.6	2.5	0.4104	0.1684
Filling	58.7	2.4	0.4556	0.2076
Fifteen	102.7	2.1	0.2742	0.0752
Warp	53.2	2.1	0.2558	0.0654
Filling	49.5	2.0	0.2769	0.0767
Twenty-five	105.6	2.1	0.3224	0.1039
Warp	53.3	2.1	0.3338	0.1114
Filling	52.3	2.1	0.3161	0.0999
For Entire Population	489.9	2.5	0.5948	0.3538

*Pounds

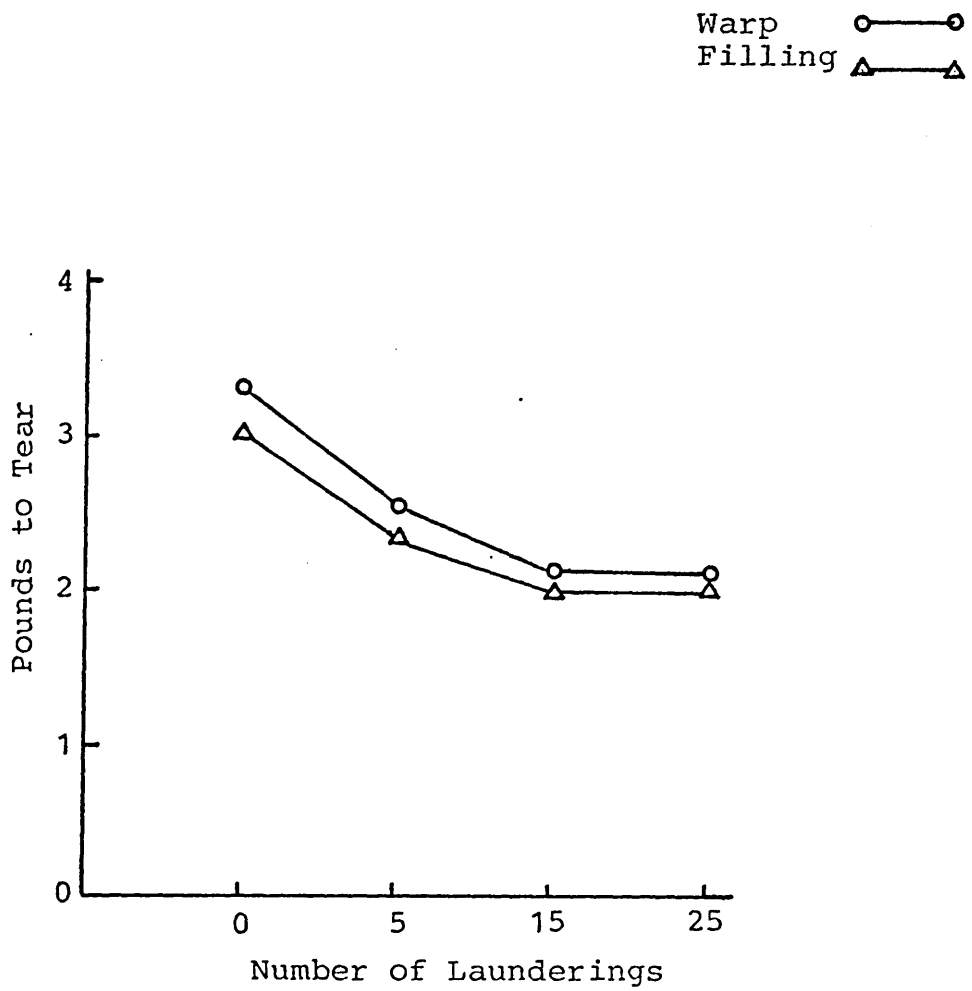


Fig. 5. Mean tearing strength values of all five fabrics initially and after 5, 15 and 25 laundering periods in the warp and filling directions.

noted between the interaction of the fabric, laundering period and yarn direction (see Table 11).

Durable Press Appearance

The durable press appearance of the experimental fabrics was rated after 1, 5, 15 and 25 laundering periods. Mean durable press values obtained from these evaluations, along with standard deviations are presented in Tables 12 and 13 and Figures 6 and 7.

The dark grey, light grey and plaid colored fabrics showed a similar trend of performance (Table 12 and Figure 6). The maroon fabric exhibited the highest overall mean score with values ranging from 3.33 after one laundering period to 2.00 after 25 laundering periods. The white fabric was slightly less acceptable after laundering with smoothness values of 2.33 after one laundering period and 1.00 after 25 laundering periods and an overall mean score of 1.58. After 25 launderings the four colored fabrics were rated identical (2.0) with regard to durable press appearance.

Table 13 and Figure 7 show the effect of laundering on the durable press appearance of all five fabrics. The mean values of all fabrics ranged from 2.6 after five launderings to 1.80 after 25 laundering periods. An overall improvement in the durable press appearance ratings of all fabrics was

TABLE 11

THREE-FACTOR ANALYSIS OF VARIANCE OF TEARING STRENGTH VALUES OF ALL FABRICS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Tail Probability
Mean	1,200.01005	1	1,200.01005	70,797.05	0.0000*
Fabric	20.74970	4	5.18742	306.04	0.0000*
Laundering Period	40.63855	3	13.54618	799.18	0.0000*
Warp-Filling Direction	1.29605	1	1.29605	76.46	0.0000*
Fabric, Laundering	3.61470	12	0.30122	17.77	0.0000*
Fabric, Warp-Filling	0.33470	4	0.08367	4.94	0.0009*
Laundering, Warp-Filling	0.32295	3	0.10765	6.35	0.0004*
Fabric, Laundering, Warp-Filling	0.73130	12	0.06094	3.60	0.0001*
Error	2.71200	160	0.01695		

*Indicates significance at $\alpha = 0.05$ level.

TABLE 12

DURABLE PRESS RATINGS OF EACH FABRIC AFTER 1, 5, 15 AND 25 LAUNDERING PERIODS

	Fabric	Number of Launderings				Mean
		1	5	15	25	
1.	Dark Grey	2.33	2.67	2.33	2.00	2.33
2.	Light Grey	2.00	2.67	2.00	2.00	2.17
3.	Maroon	3.33	3.33	2.67	2.00	2.83
4.	Plaid	2.00	2.33	2.67	2.00	2.25
5.	White	2.33	2.00	1.00	1.00	1.58

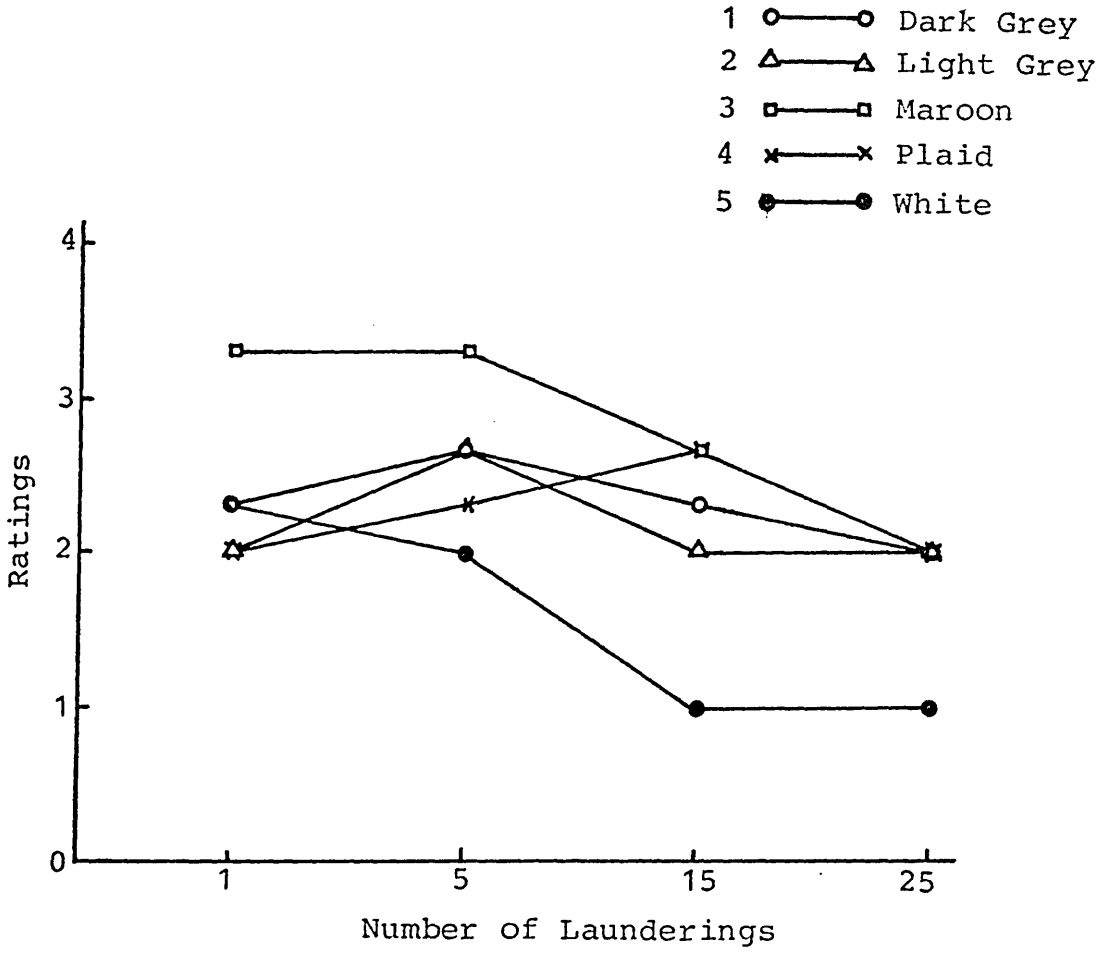


Fig. 6. Mean ratings of durable press appearance of each fabric after 1, 5, 15 and 25 laundering periods.

TABLE 13

MEAN VALUES OF DURABLE PRESS APPEARANCE OF ALL FIVE FABRICS AFTER 1, 5, 15 AND 25 LAUNDERING PERIODS

Laundering Periods	Mean	Standard Deviation
1	2.40	0.54772
5	2.60	0.49441
15	2.13	0.69121
25	1.80	0.44721

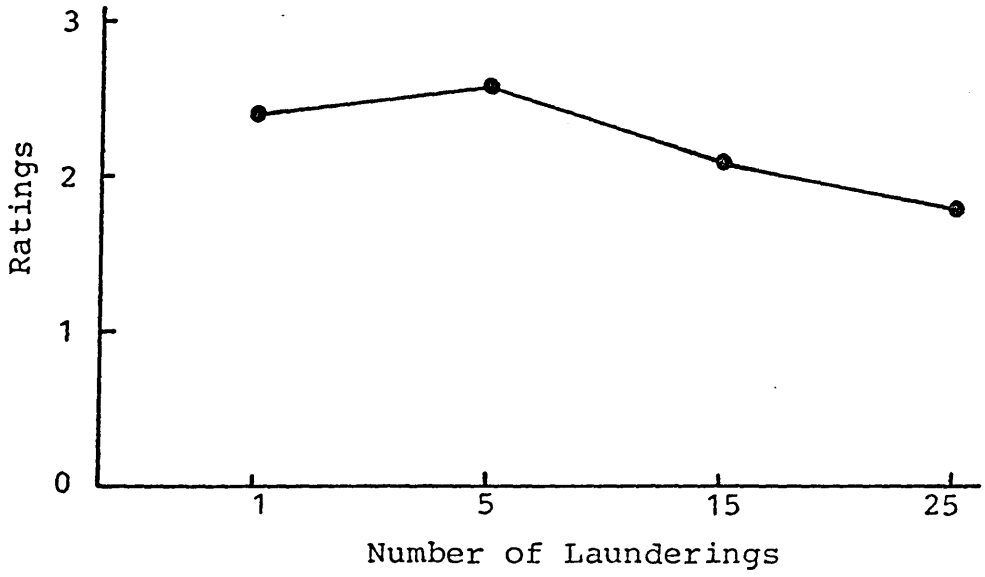


Fig. 7. Mean ratings of durable press appearance of all five fabrics after 1, 5, 15 and 25 laundering periods.

seen after five laundering periods, with slightly less acceptable ratings after 15 and 25 laundering periods.

The results of the analysis of variance test (Table 14) show that significant differences existed among fabric types and between laundering periods.

Pilling Resistance

The five experimental fabrics were subjected to the Random Tumble Pilling Test before laundering and after 25 periods of laundering. The resulting data are presented in Tables 15 and 16 and in Figure 8.

The mean data presented in Table 15 shows the pilling of the light grey and plaid fabrics to have the greatest increase of pills after 25 launderings. The light grey fabric exhibited the highest degree of resistance to pilling initially with a score of 3.67. The white fabric was less resistant to pilling initially and after 25 laundering periods than the other four fabrics, as ratings remained the same (1.78). The dark grey fabric had identical values (3.22) at both evaluation periods (see Figure 8).

The results of the analysis of variance are shown in Table 16. The factorial analysis of variance indicated no significant differences among the five fabrics and between laundering periods relative to their resistance to pilling. The interaction between fabrics and laundering periods was

TABLE 14

ANALYSIS OF VARIANCE OF DURABLE PRESS VALUES OF ALL FABRICS AFTER 25 LAUNDERING PERIODS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Tail Probability
Between Fabrics					
Mean	99.75556	1	99.75556	125.13	0.0004*
Error	3.18889	4	0.79722		
Within Fabrics					
Durable Press	1.80000	3	0.60000	4.24	0.0294*
Error	1.70000	12	0.14167		

*Indicates significance at $\alpha = 0.05$ level.

TABLE 15

MEAN PILLING RESISTANCE VALUES OF EACH FABRIC INITIALLY AND AFTER 25 LAUNDERING PERIODS

Fabric	Number of Launderings	
	0	25
1. Dark Grey	3.22	3.22
2. Light Grey	3.67	1.89
3. Maroon	3.22	3.11
4. Plaid	3.56	2.89
5. White	1.78	1.78
Mean	3.09	2.58

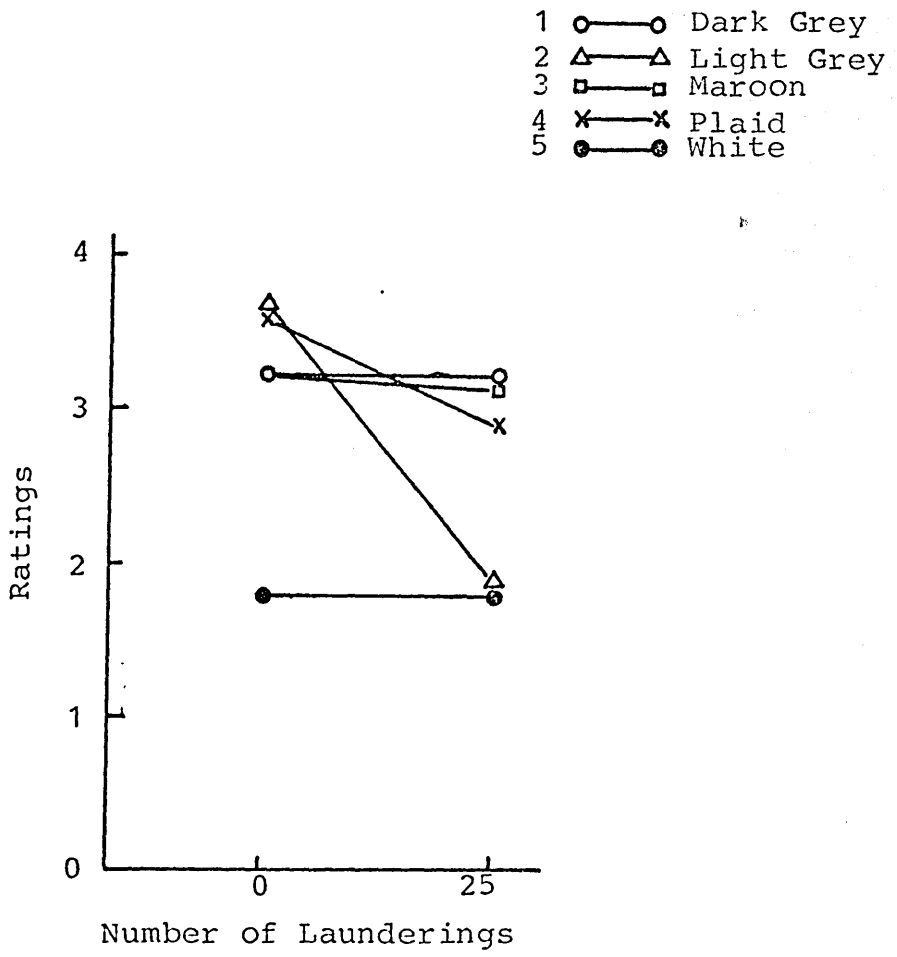


Fig. 8. Mean pilling resistance ratings of each fabric initially and after 25 laundering periods.

TABLE 16

ANALYSIS OF VARIANCE OF PILLING VALUES
OF ALL FABRICS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Tail Probability
Between Fabrics					
Mean	240.83333	1	240.83333	333.46	0.0000*
Error	10.11111	14	0.72222		
Within Fabrics					
Pilling	1.95926	1	1.95926	6.35	0.2450
Error	4.31852	14	0.30847		

*Indicates significance at α = 0.05 level.

significant, indicating that all fabrics responded differently to continued laundering. The non-laundered fabrics proved overall to be more resistant to pilling than the laundered fabrics.

Dimensional Stability

Evaluations regarding the dimensional stability of the experimental fabrics were measured after 1, 5, 15 and 25 laundering periods. Data which resulted are presented in Tables 17 and 18 and Figure 9. Table 17 shows all changes in the fabrics represented shrinkage, the greatest amount of which occurred in the warp direction of all fabric types after 25 launderings. The light grey fabric shrank the most, 16.3 percent after 25 laundering periods, while the white fabric shrank the least amount, 9.7 percent after the same number of launderings. The mean of all five fabrics' percentage of dimensional loss in the warp direction showed an increase in shrinkage as laundering periods increased.

The greatest amount of shrinkage observed in the filling direction occurred after 15 launderings for the white fabric (5.0 percent). The least amount of shrinkage was observed after 25 launderings for the dark grey fabric with no shrinkage recorded. The mean of all five fabrics' percentage of dimensional loss in the filling direction showed only slight differences in shrinkage as laundering periods

TABLE 17a

DIMENSIONAL LOSSES IN THE WARP DIRECTION OF EACH FABRIC AT DESIGNATED LAUNDERING PERIODS (PERCENT)

Fabric	Number of Launderings			
	1	5	15	25
1. Dark Grey	3.5	5.2	8.6	12.4
2. Light Grey	4.8	6.8	0.9	16.3
3. Maroon	2.6	4.0	7.0	11.4
4. Plaid	4.8	6.5	9.0	11.4
5. White	0.6	2.2	5.6	9.7
Mean	3.3	4.9	6.2	12.2

TABLE 17b

DIMENSIONAL LOSSES IN THE FILLING DIRECTION OF EACH FABRIC AT DESIGNATED LAUNDERING PERIODS (PERCENT)

Fabric	Number of Launderings			
	1	5	15	25
1. Dark Grey	0.4	0.4	0.2	0.0
2. Light Grey	3.9	3.4	3.1	3.0
3. Maroon	3.2	3.4	3.1	4.0
4. Plaid	2.4	2.5	2.6	2.8
5. White	4.2	4.7	5.0	4.5
Mean	2.8	2.9	2.8	2.9

increased. Figure 9 depicts the upward sweep of lines as warp shrinkage increased.

When a three-factor analysis of variance was applied to the shrinkage values of all fabrics, significant effects were found to exist between laundering periods and warp-filling directions. There were no significant effects among the fabric types and between fabric types and laundering periods--indicating that all fabrics experienced shrinkage when laundered. Significant effects were noted between fabrics and the warp-filling directions and between laundering period and warp-filling directions (see Table 18).

Color Evaluations

Colorfastness

The colorfastness of the four colored fabrics was determined after 5, 15 and 25 laundering periods. The laundered fabrics were compared in a specified area to the non-laundered fabric of the same type. Data presented in Table 19 and graphically illustrated in Figure 10 show that colorfastness ratings decreased as laundering periods increased for all four colored fabrics. The light grey fabric exhibited the greatest color loss after 25 laundering periods with almost 37 percent loss. The dark grey

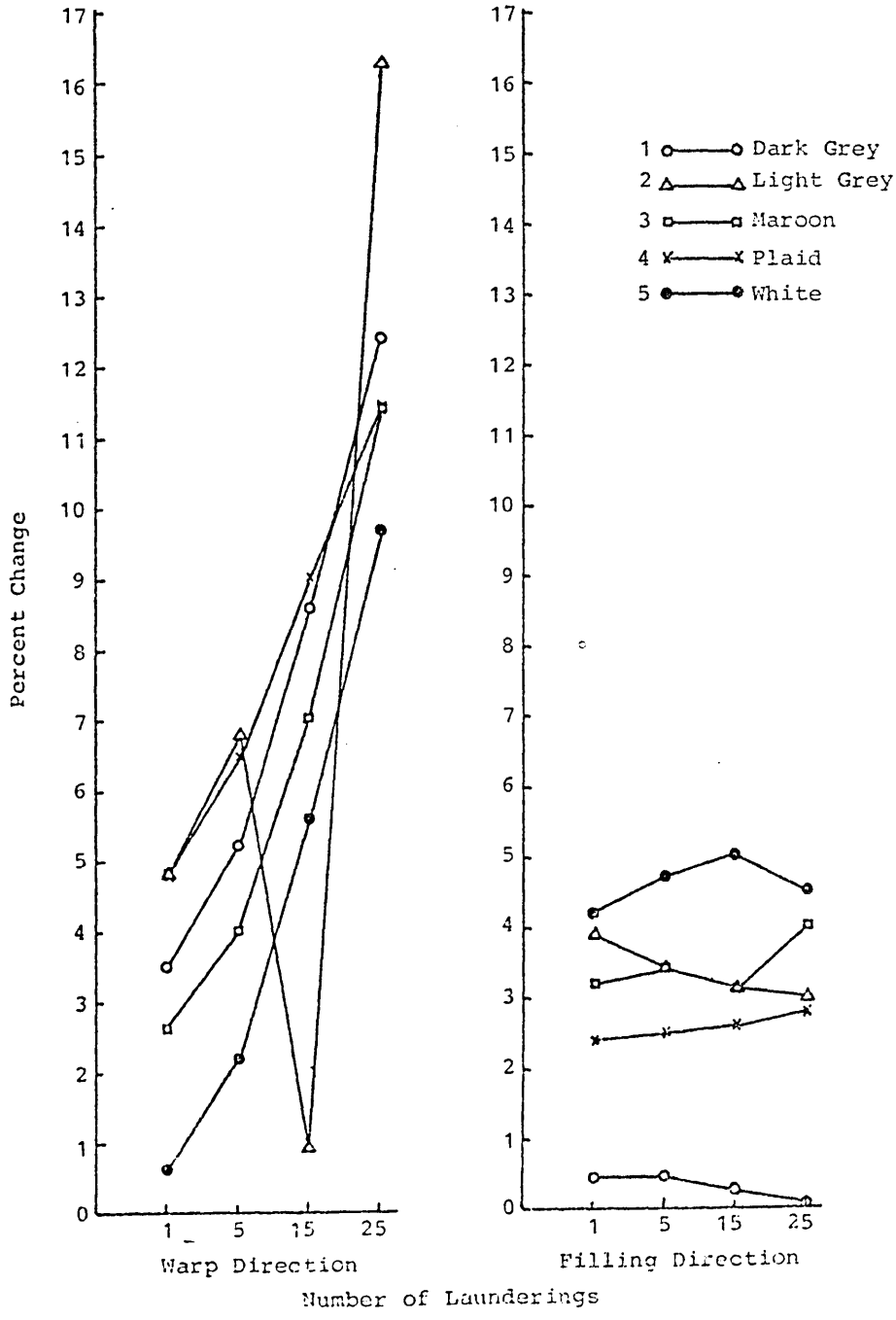


Fig. 9. Mean dimensional change of each fabric after 1, 5, 15 and 25 laundering periods in the warp and filling directions.

TABLE 18

THREE-FACTOR ANALYSIS OF VARIANCE OF PERCENT CHANGES IN DIMENSIONAL STABILITY OF ALL FABRICS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Tail Probability
Mean	826.07631	1	826.07631	281.35	0.0000*
Fabric	11.07119	4	2.76780	0.94	0.4752
Laundering Period	113.18477	3	37.72826	12.85	0.0006*
Warp-Filling Direction	138.48657	1	138.48657	47.17	0.0000*
Fabric, Laundering	33.95676	12	2.82973	0.96	0.5278
Fabric, Warp-Filling	58.56356	4	14.64089	4.99	0.0154*
Laundering, Warp-Filling	111.07882	3	37.02627	12.61	0.0007*
Error	32.29767	11	2.93615		

*Indicates significance at $\alpha = 0.05$ level.

TABLE 19

COLOR CHANGE RATINGS OF EACH COLORED FABRIC AT DESIGNATED LAUNDERING PERIODS

	Fabric	Number of Launderings			Percentage of Color Loss
		5	15	25	
1.	Dark Grey	4.83	4.33	4.00	17.18
2.	Light Grey	4.00	2.53	2.53	36.75
3.	Maroon	4.47	3.83	3.50	21.70
4.	Plaid	3.40	3.10	2.67	21.47

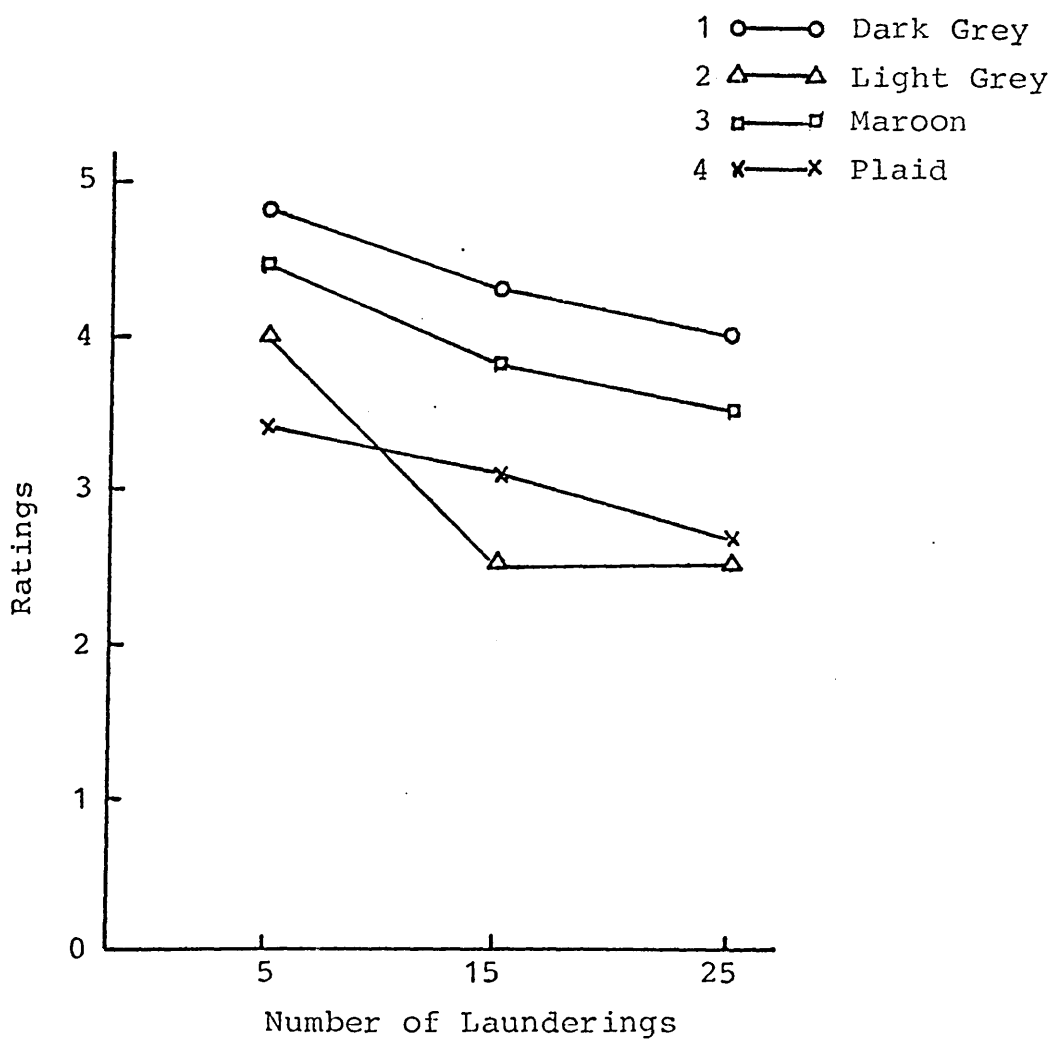


Fig. 10. Mean color ratings of each colored fabric after 5, 15 and 25 laundering periods.

fabric exhibited the best color retention after 25 laundering periods with 17.18 percent color loss. The maroon and plaid fabrics ranked in between the greys with slightly over 21 percent color loss.

The mean color loss values and standard deviations of all four colored fabrics at designated laundering periods are tabulated in Table 20. All four fabrics, as a whole, exhibited a loss of color after 5, 15 and 25 laundering periods.

The results of the analysis of variance test in Table 21 show that significant differences existed among fabric types and between laundering periods.

Whiteness Retention

The whiteness value of the white fabric was evaluated initially and after 5, 15 and 25 laundering periods. Mean whiteness values obtained from these evaluations, along with standard deviations, analysis of variance, and Newman-Keul's Multiple Comparison Test results are presented in Tables 22, 23 and 24. Figure 11 depicts a graphical description of the behavior of the white fabric at each evaluation period.

In order to determine at which laundering period the fabric was whitest the Newman-Keul's Multiple Comparison Test was applied. After five laundering periods the fabric

TABLE 20

MEAN COLOR CHANGE VALUES AND STANDARD DEVIATIONS OF ALL COLORED FABRICS AT DESIGNATED LAUNDERING PERIODS

Number of Launderings					
5		15		25	
Mean	Standard Deviations	Mean	Standard Deviations	Mean	Standard Deviations
4.18	0.59461	3.45	0.73007	3.12	0.64222

TABLE 21

ANALYSIS OF VARIANCE OF COLOR CHANGE VALUES OF ALL COLORED FABRICS AFTER 25 LAUNDERING PERIODS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Tail Probability
Between Fabrics					
Mean	197.77452	1	197.77452	190.66	0.0002*
Error	4.14919	4	1.03730		
Within Fabrics					
Color	1.58504	2	0.79252	6.06	0.0250*
Error	1.04681	8	0.13085		

*Indicates significance at $\alpha = 0.05$ level.

TABLE 22

MEAN WHITENESS VALUES AND STANDARD DEVIATIONS OF THE WHITE FABRIC INITIALLY AND AFTER 5, 15, AND 25 LAUNDERING PERIODS

Laundering Periods	Mean	Standard Deviation
0	36.96	6.47981
5	40.08	0.68702
15	17.60	1.26372
25	23.28	1.26372

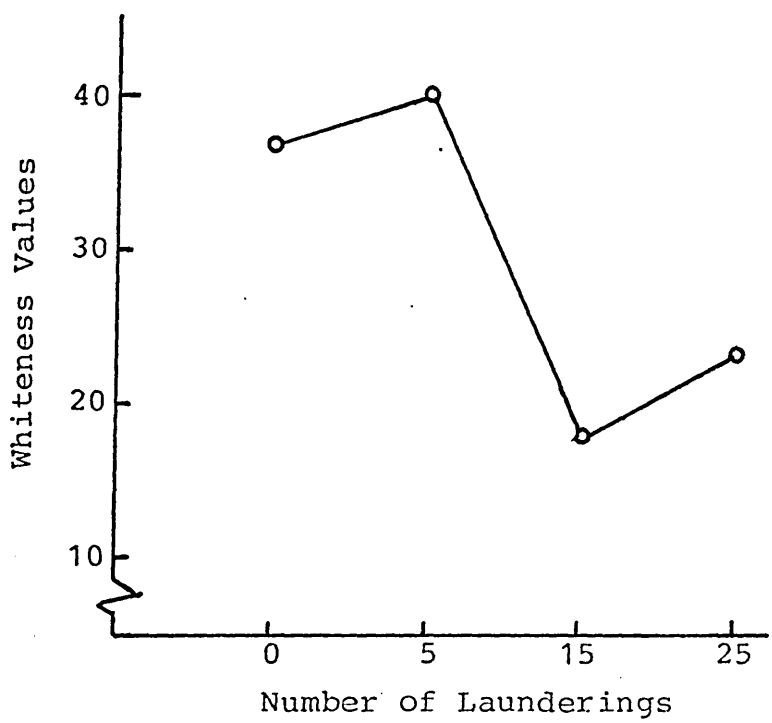


Fig. 11. Mean whiteness values of the white fabric initially and after 5, 15 and 25 laundering periods.

was significantly whiter than after 25 and 15 laundering periods. The fabric was slightly whiter after five laundering periods than before laundering but not significantly at the 0.05 level (Table 23). The one-way analysis of variance seen in Table 24 shows significant differences between the whiteness of the fabric at each evaluation period.

TABLE 23

NEWMAN-KEUL'S MULTIPLE COMPARISONS OF THE WHITENESS VALUES OF THE WHITE FABRIC AT DESIGNATED LAUNDERING PERIODS

Laundering Period	5	0	25	15
Mean	40.1	37.0	23.3	17.6

Note: There is a significant difference at the $\alpha = 0.05$ level in the laundering period not underlined by the same line.

TABLE 24

ANALYSIS OF VARIANCE OF WHITENESS VALUES
OF THE WHITE FABRIC

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	F-Probability
Between Fabrics	3	1,739.4240	579.8080	47.543	0.0000*
Within Fabrics	16	195.1280	12.1955		
Total	19	1,934.5520			

*Indicates significance at the $\alpha = 0.05$ level.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

The purpose of this study was to investigate the physical properties and wash-and-wear performance of Viyella, a 55 percent wool and 45 percent cotton intimate blend fabric, during home-type laundering periods. Five pieces of Viyella, of five different colors, were used as experimental fabrics. There were approximately 3½ yards of each of the five colors. The fabrics were a twill weave, 2-up and 2-down, and were all of comparable weights and yarn counts.

Properties investigated before laundering included fiber content, yarn structure, fabric weave, fabric weight and fabric yarn count. Tests which were performed included breaking strength, tearing strength, durable press appearance, pilling resistance, dimensional stability, colorfastness and whiteness retention.

The data obtained from the tests were analyzed by means of a "factorial" repeated measures design. The factors were fabric type, warp or filling yarn directions, and the specific laundering period with respect to the test performed. The analysis of variance was used to determine

where differences in the factors existed at the 0.05 level of significance.

The results of the physical properties tests revealed the experimental fabric to be a wool and cotton intimately blended twill weave. All five fabrics were of comparable weight and yarn count. The spun yarn had a Z twist and single yarn structure.

The statistical analysis of data revealed the maroon fabric to have the highest breaking strength values both in the warp and filling directions of 44.2 and 45.6 respectively, when all laundering periods were combined. The dark grey fabric had the lowest mean breaking strength when all laundering periods were combined with values of 30.0 in the warp direction and 30.8 in the filling direction. The fabrics, as a whole, showed better resistance to breaking in the warp direction initially and after five laundering periods; whereas, the fabrics showed higher breaking strength properties after 15 and 25 launderings in the filling direction. The analysis of variance indicated significant effects existed among fabric types, laundering periods and warp and filling yarn directions.

Significant effects were also noted between the interaction of the fabric, laundering period and yarn direction.

When all laundering periods were combined the light grey fabric had the highest tearing strength values (2.9 pounds) both in the warp and filling directions. The dark grey fabric had the lowest mean tearing strength when all laundering periods were combined with values of 2.1 in the warp direction and 1.9 in the filling direction. The fabrics, as a whole, showed better resistance to tearing in both the warp and filling directions initially and became less resistant to tearing as laundering periods increased. The analysis of variance indicated significant effects existed among fabric types, laundering periods and warp and filling yarn directions. Significant effects also were noted between the interaction of the fabric, laundering period and yarn direction.

The data for durable press appearance revealed that after one laundering period the maroon fabric exhibited the highest mean score and the white fabric exhibited the lowest mean score with smoothness values of 3.33 and 2.33 respectively. After 25 launderings the four colored fabrics were rated identical (2.0). The white fabric was slightly less acceptable after 25 launderings (1.0). An overall improvement in the durable press appearance ratings of all fabrics was indicated after five laundering periods, with slightly less acceptable ratings after 15 and 25 laundering periods.

The results of the analysis of variance test show that significant differences existed among fabric types and between laundering periods.

The light grey and plaid fabrics had the greatest increase in pills after 25 laundering periods. The light grey fabric exhibited the highest degree of resistance to pilling initially with a score of 3.67. The white fabric was less resistant to pilling initially and after 25 launderings than the other four fabrics, as ratings remained the same (1.78). The dark grey fabric revealed identical values (3.22) at both evaluation periods. The interaction between fabrics was significant, indicating that all fabrics responded differently to continued laundering.

Evaluation of the dimensional stability of the experimental fabrics showed that the greatest amount of shrinkage occurred in the warp direction of all fabric types after 25 launderings. In the filling direction the greatest amount of shrinkage occurred after 15 launderings for the white fabric. Significant effects were found to exist between laundering periods and warp-filling directions. There were no significant effects among the fabric types and between fabric types and laundering periods--indicating that all fabrics experienced shrinkage when laundered. Significant effects were noted between fabrics and the warp-filling

directions and between laundering period and warp-filling directions.

Colorfastness ratings decreased as laundering periods increased for all four colored fabrics. The dark grey fabric exhibited the best color retention after 25 laundering periods with 17.18 percent color loss. The light grey fabric exhibited the greatest color loss after 25 laundering periods with almost 37 percent loss. Significant differences existed among fabric types and between laundering periods.

The data for whiteness retention revealed that an erratic loss of whiteness took place at each evaluation period for the white fabric. Newman-Keul's Multiple Comparison Test showed the fabric to be significantly whiter after five laundering periods than after 25 and 15 laundering periods. Significant differences were observed between the whiteness of the fabric and the evaluation period.

Recommendations

Based on the findings of this study, the following recommendations are suggested:

1. That a similar study be conducted using different laundering procedures.

2. That a similar study be conducted comparing dry cleaning methods and home-laundering procedures.

3. Laundering methods recommended by the manufacturer and care labels found on fabrics should be consistent.

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