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The major objective of this thesis was to determine the relation between yarn characteristics and the wrinkle recovery of selected sheeting made from cotton fibers with varying properties of length and strength. Yarn characteristics were determined by measuring yarn number and yarn diameter. Wrinkle recovery was measured by the Monsanto Wrinkle Recovery Tester.

Sheets sampled for this study were those which had been used at the University of North Carolina at Greensboro, as part of Phase II of Southern Regional Research Project SM-18. A total of 240 sheets which had been withdrawn from the project following 0, 5, 15, 30, 45, and 60 periods of use and laundering and following 0, 5, 15, 30, 45, and 60 periods of laundering only were used for testing. Measurements of both warp and filling yarns were obtained in the tests for yarn number, yarn diameter, and wrinkle recovery. An analysis of variance which was the statistical procedure developed for Southern Regional Project SM-18 was used to analyze the data and to determine the F ratios. Correlation coefficients were computed to determine the relationship between yarn characteristics and wrinkle recovery.

The results of this study indicated that yarns became progressively smaller in size after use and laundering and

after laundering only as indicated by yarn number and yarn diameter. The yarn size of the cottons in the laundered and used set decreased more than those in the laundered only set as indicated by the tests. The wrinkle recovery of the sheets in the laundered and used set was greater than the wrinkle recovery of the sheets in the laundered only set. Generally there were no significant differences in yarn number, yarn diameter, or wrinkle recovery between cottons varying in length and strength after use and laundering and after laundering only. Changes in yarn characteristics as indicated by yarn number and yarn diameter were not closely related to changes in wrinkle recovery of the sheeting.

THE RELATION OF YARN CHARACTERISTICS OF SELECTED COTTON SHEETING TO WRINKLE RECOVERY

by

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APPROVAL SHEET

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CHAPTER I

INTRODUCTION

Cotton is regarded by many as the most versatile of all fibers, natural or synthetic, having more end uses than all other fibers. The end use consumption of cotton in 1965 was 51.2 per cent of the total market of textile fibers.[1] Yet in the past three decades cotton producers have faced a strong challenge from manufacturers of synthetic fibers. To meet this challenge they have constantly sought new improvements in cotton fiber quality and in the serviceability of cotton products. However, little or no experimentation has involved long term study of products in actual consumer use. Recent research undertaken as a cooperative research project through the Agricultural Experiment Stations of the Southern Region was designed to meet this need.

I. THE PROBLEM

Background of the Problem - Summary of Regional Project SM-18

The research of Regional Project SM-18 has been conducted to study the effects that certain fiber properties

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[1] "Textile Fiber End Use Survey, 1965," Textile Organon, 38:4, January, 1967.

might have on the performance characteristics of cotton sheeting. This research was divided into two parts. Phase I was concerned with the relation of fiber elongation to the performance of sheeting made from selected cottons similar in properties of length, strength, and fineness, but varying in elongation.[2] Phase II was concerned with the relation of fiber length and strength to the performance of sheeting similar to that studied in Phase I.

In Phase II of the Southern Regional Project SM-18, eight bales of experimental cottons were selected to measure two levels of length (long and short staple) and two levels of strength (low and high strength). The School of Textiles, Clemson College, manufactured the eight bales of cotton into type 140 sheeting fabric. All servicing of the sheets was carried out at four southern universities. The sheets to be tested were divided into two groups. One group was used in women's dormitories for one week and then commercially laundered. A second group was not used in the dormitories, but was laundered weekly following the same schedule as the used sheets.

Statement of the Problem

This thesis was a contribution to Phase II of the Regional Research Project. Previous research indicated a

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[2]Southern Cooperative Series, "Performance of Sheets Made from Low and High Elongation Cotton," Bulletin No. 106, August, 1965, p. 7.

need for further investigation of the yarn characteristics of the sheeting made from selected cottons and the relation these characteristics might have upon product performance in consumer use. The objectives of this study were:

1. To determine the yarn characteristics of experimental cotton sheeting made from cottons with two levels of length and two levels of strength as measured by yarn number and yarn diameter.

2. To determine the wrinkle recovery of experimental cotton sheetings made from cottons with two levels of length and two levels of strength.

3. To determine the relation between yarn characteristics and the wrinkle recovery of the selected cotton sheeting.

All experimentation was limited to the two groups of cotton sheeting used in Phase II of the Regional Project, one of which had been used and laundered, the other subjected to laundering only. Both groups were sampled following 0, 5, 15, 30, 45, and 60 periods.

The statistical treatment of the data included:

1. An analysis of variance to determine significant differences in fiber properties of length and strength as measured by yarn number, yarn diameter, and wrinkle recovery.

2. Correlation of coefficients to determine any relation between wrinkle recovery as measured by the Monsanto Wrinkle Recovery Tester and yarn characteristics as measured by yarn number and yarn diameter.

II. DEFINITIONS OF TERMS USED

Yarn Number

A measure of weight per unit length of a yarn. Yarn number of cotton is the number of 840 yard hanks in one pound.

Yarn Diameter

A measure of the diameter of a longitudinal section of a yarn.

Wrinkle Recovery

The ability of a fabric to eliminate wrinkles by its own resiliency.

Fabric Geometry

The relation of inherent fiber properties to the ultimate properties of the textile structure.

Untreated Cotton Sheeting

That sheeting which has had no chemical finish applied to it.

CHAPTER II

REVIEW OF LITERATURE

Many factors are involved before a fiber, whether synthetic or natural, becomes a fabric which is both satisfactory and satisfying to its user. Several hypotheses have been forwarded concerning factors which influence the wrinkle recovery of untreated cotton fabrics, but a review of literature reveals that little actual research has been conducted.

I. WRINKLE RECOVERY

Definitions

In the textile industry today the terms crease resistance, wrinkle resistance, and wrinkle recovery are used synonomously. In 1949 Buck and McCord defined crease resistance as:

> . . . That property of a fabric which causes it to recover from folding deformations that normally occur during its use. The recovery may be almost instantaneous in which case there will be an apparent resistance to the formation of a crease. The speed and completeness of a fabric's recovery from creases is the measure of its crease recovery.[1]

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[1] George S. Buck, Jr. and Frank A. McCord, "Crease Resistance and Cotton." Textile Research Journal, 19:8, April, 1949.

Cotton and Wrinkle Recovery

Wrinkle recovery is an important fabric quality, and has received attention from textile scientists for a number of years. Because of cotton's natural affinity to wrinkling, it was one of the first fibers to receive attention.

> In cotton, improvements in this property are obtained by chemical finishes which improve the ability of fibers to maintain the configurations in which they are treated.
>
> The first attempts to improve cotton fabric recovery from wrinkling by chemical finishing date back to the 1920's. However, undesirable side effects of treatment prevented its commercial utilization at that time. Considerably less than one percent of cotton fabric production was finished for wrinkle resistance in 1948. The great acceleration in the pace of research and development came in the early years of the past decade. . . . Spurred by claims made for synthetic fiber fabrics, research aimed at the development of wash and wear cottons was intensified. By 1955 they appeared on the market in volume.[2]

In the past decade cotton wash and wear fabrics have found increased usage. Though chemical finishes impart the desired wrinkle resistant characteristics to the fabric, many untreated cottons are found on the market today.

Methods for Evaluating Wrinkle Resistance

There are several laboratory methods for determining the wrinkle resistance of textile fabrics. Buck and McCord have summarized these in their study of "Crease Recovery and Cotton."

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[2]Henry Tovey, "Wrinkle Resistance and Recovery from Deformation," Textile Research Journal, 31:185, March, 1961.

During the past twenty years at least a dozen methods for evaluation of fabric crease-resistance have been suggested, both in this country and abroad. . . .

If the crease-resisting characteristics of fabrics are to be improved, comparative tests must be available so that the relative crease-resistance of a treated fabric to an untreated one can be determined. . . . The ultimate development in test methods would be a method that could duplicate the creasing which occurs during actual garment use, and which would provide data which could be correlated with the performance of a fabric in a garment. . . .

. . . A brief description of a number of testing methods that have been used for evaluating textile crease-resistance will be set down here. . .:[3]

1. Clenched-Fist Method - A specimen of cloth, about a foot square, is crumpled by squeezing the small wad of fabric in the clenched fist.

2. T-B-L Method - A fabric cutting 4cm long and 1 cm wide is folded across a narrow dimension and placed beneath a 500 gram weight for five minutes, then allowed to recover over a horizontal wire for three minutes. The distance between the ends is taken as the measure of crease resistance of the specimen.

3. Mercury Method - A small cutting of fabric is folded across a short dimension and placed under a standard weight. After a specified time, the weight is removed and folded cutting is floated on a surface of mercury, and allowed to recover. The angle of creasing or the distance between the ends can be measured.

4. Creasing-Angle Method - Modification of the T-B-L Method and involves measurement of the angle of the crease.[4]

Continuing, Buck and McCord describe the Monsanto Method, which was the method of evaluating wrinkle resistance used in this study:

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[3]Buck and McCord, op. cit., pp. 18-19.

[4]Ibid., p. 19.

> A modification of the creasing-angle designed to minimize some of the variables of earlier techniques. . . . In this method one end of the creased cutting is held firmly in a jaw while the other hangs free and is brought into coincidence with the vertical line of the meter. The angle which the free end makes with the clamped end after a specified time of suspension on the meter is a measure of the recoverability of the fabric. The influence of fabric weight and stiffness is largely eliminated. . . . The instrument is simple yet well designed, is portable, and gives results that are adequate for most developmental or merchandising purposes.[5]

II. STUDIES OF FABRIC GEOMETRY

Most authorities agree that fiber, yarn and fabric geometry play an important role in the end use performance of all textile products.

> The preparation and performance of any textile structure is dependent upon a combination of inherent fiber properties, as well as upon the geometrical arrangement of fibers in yarns and yarns in fabric. A most significant requirement is the ability of the fiber to be converted to a yarn, and the ability of the resulting yarns to be converted into a fabric. Inherent fiber properties can and do affect the geometry of translation. The most important aspect is the effect of geometry on the ultimate properties of the textile structure.[6]

Influence of Fiber Properties on Wrinkle Recovery

Fibers form the basic unit from which all textile fabrics are developed. The importance of fiber size, length, strength, and elasticity upon wrinkle recovery has received considerable attention from textile technologists.

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[5] Ibid., pp. 20-21.

[6] E. R. Kaswell, Textile Fibers, Yarns, and Fabrics (New York: Reinhold Publishing Corporation, 1953), p. 175.

Buck and McCord suggested "that the greatest influence upon wrinkle recovery is the type of fiber used in the yarn."[7] The size of the fiber, as measured by the diameter, affects the wrinkle resistance of cotton fibers. Marsh believes that the greater the diameter of the fiber, the less creasing occurs.[8] Buck and McCord agree that fibers with larger diameters have greater bending and torsional rigidity with which to resist deformation.[9]

Fiber length, fiber strength and fiber elasticity are determining factors in the wrinkle recovery of fabrics. Buck and McCord comment:

> . . . When fibers are too short, fiber-to-fiber cohesion in yarns is low and folding may displace fibers in yarns so that failure to return to the original position produces permanent deformation. Exceptionally long staples have little advantage over medium length fibers, except that twist is at a minimum and there is a better chance that the elastic limit of the fiber is not exceeded.[10]

> Textile fibers are composed of long chain-like molecules. When groups of molecules are so aligned that the bundles formed have crystal properties, they are called crystallites. A high degree of crystallinity, such as is present in cotton cellulose (80-90%) influences the flexibility and the extensionibility of the fiber. Cottons of high strength tend to be least extensible and flexible, and wrinkle more easily.[11]

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[7]Buck and McCord, op. cit., p. 9.

[8]J. T. Marsh, Crease Resisting Fabrics (New York: Reinhold Publishing Corporation, 1953), p. 35.

[9]Buck and McCord, op. cit., p. 13.

[10]Ibid.

[11]Ibid., p. 9.

Influence of Yarns on Wrinkle Recovery

In a paper presented at a meeting of the Textile Research Industry in 1950, E. R. Schwarz pointed out the importance of yarn characteristics upon end use performance of fabrics:

> Yarns form basic units which relate the properties of fiber to the properties of fabrics. Their geometry and structure should be well understood, since they may modify behavior of fabrics by reducing or enhancing the properties of the fiber used.[12]

Tovey, in his description of wrinkle resistance and recovery from deformation, agrees with this theory. "Fabrics made from the same fiber but of different construction may differ by over fifty percent in crease recovery. The selection of appropriate yarn is, consequently, extremely important for the deformation recovery of the final product."[13]

Yarn Number

Yarn size appears to influence the wrinkle recovery of untreated cotton. One method for measuring yarn size is by determining yarn number. Yarn number is defined by ASTM Committee D-13 Textile Materials as:

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[12] E. R. Kaswell, Textile Fibers, Yarns, and Fabrics (New York: Reinhold Publishing Corporation, 1953), p. 175, citing E. R. Schwarz, "Certain Aspects of Yarn Structure" (paper read at Textile Research Institute Meeting, New York, New York, November 1950).

> A measure of linear density (weight per unit length) of yarn and hence a conventional relative measure of fineness or dimension. It may be expressed in a direct system where the number increases as the yarn becomes coarser, or in an indirect system where the number decreases for coarser yarn.[14]

The Tex Yarn Numbering System

Through the years several systems were used in the textile industry for numbering yarns; as a result, much confusion arose within the industry. In order to rectify the situation, the Technical Committee on Textiles of the International Organization for Standardization began an investigation to determine "a plan for the orderly introduction of a single system of numbering yarns made from all types of fibers."[15] The Tex system which developed as a result of this investigation to replace the conflicting system is now used.

The change over from the conventional system will be made in three stages over a period of years. The first stage which began in 1960, was designed to familiarize everyone working in the industry with the Tex system. The existing systems will still be used, but a corresponding rounded Tex number will be given in parentheses after the traditional yarn number. In the second stage, commercial transactions

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[14]ASTM Committee D-13 on Textile Materials, ASTM Standards on Textile Materials, 34th Edition, 1963, p. 807.

[15]1966 Book of ASTM Standards, "Use of the Tex System Designate Linear Density of Fibers, Yarn Intermediates, Yarns, and Other Textile Materials" (Philadelphia, Pennsylvania: American Society for Testing and Materials, 1966), p. 149.

and manufacturing operations will be shifted to the Tex system. The traditional yarn number will be given in parentheses after the Tex number. In the third stage, only the Tex number will be given with the traditional yarn number deleted.[16]

Definition of Yarn Systems and Conversion Factor Used in This Study

"The Tex system for measuring the linear density of yarns is a direct system based on mass per unit weight. The Tex unit is equal to the mass in grams of one kilometer of yarn."[17]

The English system which is an indirect system for numbering cotton yarns was used in this study. "For yarns . . . in the English system, the yarn number is measured by the number of 840 yard hanks in one pound of material.[18]

ASTM Committee D-13 has determined conversion factors for various indirect yarn numbers to the exact Tex equivalents.

> The following equation may be used to calculate yarn number in Tex units equivalent to yarn number observed in various indirect systems (length per unit weight systems):

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[16] *Ibid.*

[17] *Ibid.*, p. 144.

[18] ASTM Committee D-13 on Textile Materials, *op. cit.*, p. 359.

$$\text{Yarn number in Tex Units} = \frac{590.541}{\text{cotton hank number}}$$ [19]

Yarn Diameter

Another method of determining yarn size is by measurement of the diameter of the yarn. B. L. Banerjee, in an article reported in The Indian Textile Journal in 1958, defined the term yarn diameter.

> The term diameter is used to denote the average extent of the core of a yarn across its length without the projecting hairs. The diameter of a yarn can be measured by means of either a microscope or a suitably calibrated photo-electric instrument. In measurement with the former, the width of the core leaving out the projecting hairs is regarded as the diameter.[20]

Buck and McCord in their study of crease resistance suggested that yarn size influenced the wrinkle recovery of textile fabrics.

> The coarseness of the yarn also affect a fabric's ability to resist creasing. Coarse yarns cannot be creased as sharply as fine yarns, and therefore the strain on the fibers will be less. Moreover, there will be more fibers in a given cross section of a coarse yarn than of a fine yarn, and therefore a better distribution of stress. Still another factor in favor of the coarse yarn is the lower twist generally used in heavier construction.[21]

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[19] 1966 Book of ASTM Standards, op. cit., p. 146.

[20] B. L. Banerjee, B. N. Bhattacharyya and M. K. Sen, "The Study of Yarn Properties in Relation to Structure and Appearance of Hessian," The Indian Textile Journal, 68:476, May, 1958.

[21] Buck and McCord, op. cit., p. 14.

Yarn Construction

Yarn construction is an important aspect of fabric geometry. Webb and Richardson believe that high strength cottons produce stronger yarns than low strength cottons for any given yarn number.[22] The arrangement of the fibers in the yarn affects the wrinkle recovery properties. The multifilament character of yarns is essential to minimize the strains on individual fibers. Finer fibers will produce a better stress distribution for a given count of yarn. This combined with low twist, low count, and high crimp lead to better crease recovery in yarns.[23]

Influence of Fabric Construction on Wrinkle Recovery

The wrinkle recovery of textile fabrics is affected by their construction. The stability of fabrics related to the capability of the fabric to retain its dimensions after laundering. Cotton fabrics lose their original shape because cotton swells and tends to shorten longitudinally. As a result, a more compact structure is obtained which wrinkles to a greater degree.[24]

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[22]Louis A. Fiori, John J. Brown, and Jack E. Sand, "Effect of Cotton Fiber Strength on Single Yarn Properties and on Processing Behavior," Textile Research Journal, 24: 507, June, 1954, citing R. W. Webb and H. B. Richardson, "Relation of Count-Strength Produce of Long-Draft Processed Yarn to Six Elements of Cotton Quality and Yarn Size" (Washington, D. C.: Production and Marketing Administration, USDA, 1950), (Mimeographed).

[23]P. B. Upadhyay, "Effect of Yarn Twist and Fabric Cover Factor on Crease Recovery and Tear Strength," American Dyestuff Reporter, 50:667, September 4, 1961.

[24]A. L. Lippert, "Characteristics of Wash and Wear Cotton," Textile Research Journal, 26:135, February, 1956.

A more relaxed construction which permits yarn flexibility is more conducive to recovery from deformation.[25] Low yarn count in fabrics also contributes to a freedom of motion and lack of strain which gives high crease recovery. Fabrics of coarse yarns are more naturally resilient than those of fine yarns.[26]

III. SUMMARY

A review of the literature revealed that little research has been conducted concerning the relationship of yarn characteristics to the wrinkle recovery of untreated cotton fabrics. The literature did reveal, however, the importance of such components of fabric geometry as fiber strength and length, yarn size and fabric flexibility upon wrinkling characteristics of textile products.

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[25] E. W. Lawrence, "Wash and Wear Fabrics," American Dyestuff Reporter, 45:550, August 13, 1956.

[26] Lippert, op. cit., p. 129.

CHAPTER III

PROCEDURE

This study was an outgrowth of Phase II of the Southern Regional Research Project SM-18. The purpose of Regional Project SM-18 was to investigate the relationship between fiber properties and end use performance of fabrics made from selected types of cotton. Phase I of the project was concerned with the property of fiber elongation. Phase II was concerned with the properties of length and strength. Fiber specification for the high-low values of length and strength were established by textile research laboratories at Auburn University, Louisiana State University, and the University of Tennessee and are shown in Table I. As part of Phase II this study is being conducted to determine the relationship of yarns made of cotton fiber with two levels of length and two levels of strength to the wrinkle recovery of untreated cotton sheeting which (1) has been used and laundered and (2) has been laundered only.

Sampling Plan

Sheets tested in this study were those which were used as part of Phase II of Regional Project SM-18 at the University of North Carolina at Greensboro. The sheets sampled

TABLE I

FIBER SPECIFICATIONS FOR BALES - REGIONAL PROJECT SM-18*

Bales	Length		Strength	
	Staple	Inches	PSI	Fineness Micronaire
1 & 2	Short	7/8 - 1	Low - 70,000	4.6 - 5.0
3 & 4	Short	7/8 - 1	High - 80,000	4.6 - 4.8
5 & 6	Long	1-1/16 - 3/32	Low - 83,000	4.5 - 4.6
7 & 8	Long	1-1/16 - 3/32	High - 93,000	4.4 - 4.6

* Manual of Procedures, Regional Textile Research Project SM-18, p. 1.

were those which were withdrawn following 0, 5, 15, 30, 45, and 60 periods of use and laundering (designated as LU) and following 0, 5, 15, 30, 45, and 60 periods of laundering only (designated as LO). Three sheets of each cotton were sampled, making a total of twenty-four sheets tested at each period of use and laundering. Two sheets of each cotton were sampled at each period of laundering only making a total of sixteen sheets in the set designated as laundered only.

The samples to be used for measuring yarn number, yarn diameter and wrinkle recovery were taken from the center portion of the sheet which had received wear during use. Four 1¼ x 15 inch strips were cut from each sheet and from these twelve warp and twelve filling yarns were taken to measure yarn number and yarn diameter. Six test samples 1.5 cm. wide and 4 cm. long were cut from both warp and filling directions of each sheet to measure wrinkle recovery. Figure 1 shows the placement of samples tested.

Determination of Yarn Number

The Suter Universal Yarn Numbering Balance was used to determine yarn number. This balance was selected because the samples to be weighed were completely housed protecting them from drafts.[1]

[1]Universal Yarn Numbering Balance Instruction Sheet," (New York: Alfred Suter Textile Engineer).

TOP OF SHEET

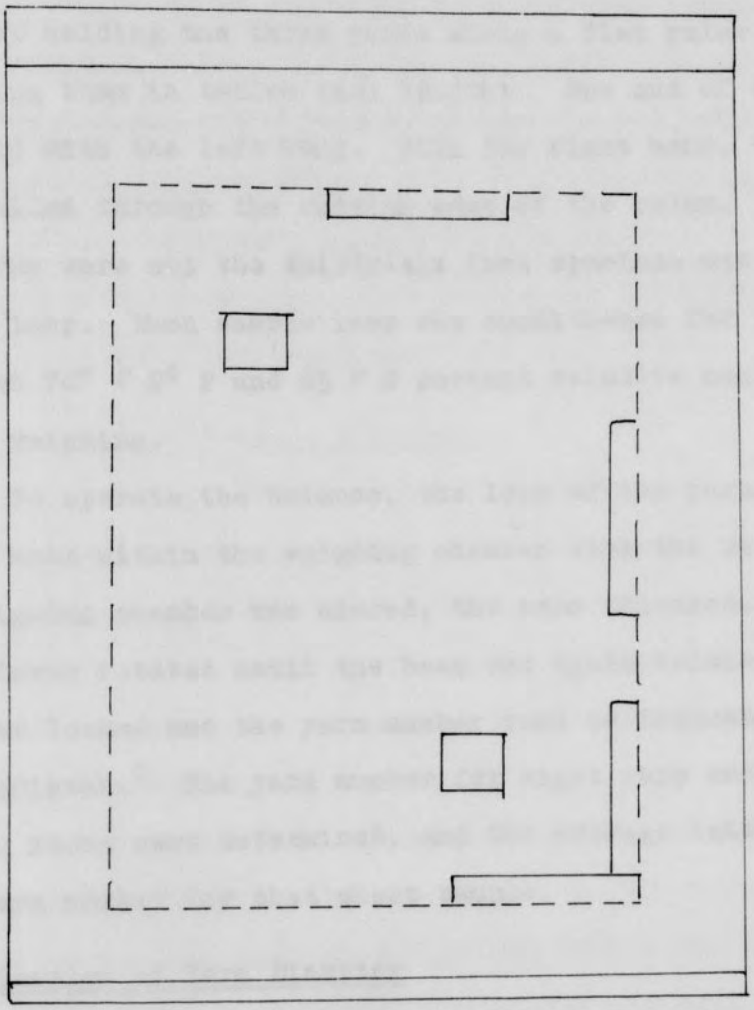

FIGURE 1

PLACEMENT OF SAMPLES TESTED

- - - Worn area of sheet

——— Samples used for yarn number and yarn diameter ($1\frac{1}{4}$ x 15")

▭ Samples used for wrinkle recovery

Each yarn specimen consisted of three twelve inch yarns, totaling thirty-six inches. Yarn specimens were prepared by holding the three yarns along a flat ruler and measuring them in twelve inch lengths. One end of the yarn was held with the left hand. With the right hand, the yarns were pulled through the cutting edge of the ruler. After the yarns were cut the thirty-six inch specimen was formed into a loop. Each sample loop was conditioned for twelve hours at 70° ± 2° F and 65 ± 2 percent relative humidity before weighing.

To operate the balance, the loop of the yarn was hung on the hook within the weighing chamber with the beam locked. The weighing chamber was closed, the beam unlocked, and the index lever rotated until the beam was again balanced. The beam was locked and the yarn number read as indicated by the index pointer.[2] The yarn number for eight warp and eight filling yarns were determined, and the average taken for the mean yarn number for that sheet sample.

Determination of Yarn Diameter

The Visopan Micro Projector was used to measure the diameter of the sample yarns. This instrument was selected because the built-in Fresnel lens provided uniform illumination on a large screen (8 in. 200 mm diameter).[3]

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[2] Ibid.

[3] "Visopan Instruction Sheet," (West Caldwell, N. J.: William J. Hacker and Company, Inc.).

Ten warp and ten filling yarns for each sheet were randomly selected to determine yarn diameter and held in place on glass slides by transparent tape. The slides were placed under the 50X objective of the Visopan and each yarn was measured in three places using a transparent measuring scale 100 mm. in length which was attached to the projector. The mean of these thirty measurements was recorded as the diameter of the individual yarns for that sheet.

Determination of Wrinkle Recovery

The Monsanto Wrinkle Recovery Tester is an instrument used to estimate the wrinkle recovery of woven fabrics. The test is conducted with the following factors controlled: relative humidity, temperature, pressure applied to the fold, time under pressure, and recovery time. Specimens were handled with tweezers during the testing.[4]

The samples to be tested were placed between the leaves of the plastic holder with one end directly under the 1.8 cm. mark. The exposed end of the sample was lifted over the 1.8 cm. mark on the short metal leaf and held in place with the left thumbnail. The holder and sample were placed in a plastic press, so that the jaw having the small raised platform was outside of and parallel to the longer metal strip of the holder. The edge of the flat thicker jaw was

[4]Manual of Procedures, Regional Textile Research Project SM-18, p. 45.

brought into contact with the specimen, pressing just firmly enough to hold the sample. The press-holder combination was inverted on a table top with the small platform upward and a 500 gram load was applied to the platform. After exactly five minutes, the load was removed and the sample in its specimen holder was inserted into the clamp on the tester. The press was removed and the specimen holder was adjusted by aligning the crease in the sample with the vertical guide line in the center of the tester. For the next five minutes, the specimen was kept aligned with the vertical guide line. Final adjustment was made after exactly five minutes and the wrinkle recovery value was recorded.[5] The results were averaged and the mean reported for warp and filling of each sheet.

Analysis of Data

The statistical procedure used in this study was the analysis of variance. The computer program which was developed for the Southern Regional Research Project SM-18 was used to analyse all data and to determine the F ratios. The analysis of variance was used to test the significance of differences in cottons with two levels of length and two levels of strength as measured by yarn number, yarn diameter, and wrinkle recovery after 0, 5, 15, 30, 45, and 60 periods of use and laundering and after 0, 5, 15, 30, 45, and 60 periods of

[5] Ibid., p. 45.

laundering only. Findings were considered significant at the .05 level and highly significant at the .01 level.

Correlation coefficients to determine any relation between the degrees of wrinkle resistance and the corresponding yarn number and yarn diameter were calculated using Pearson's Product Moment Correlation.

CHAPTER IV

PRESENTATION OF DATA

The major objective of this thesis was to determine the relation between yarn characteristics and the wrinkle recovery of selected sheeting made of cotton fibers with varying properties of length and strength. Yarn characteristics were determined by measuring yarn number and yarn diameter. Wrinkle recovery was measured by the Monsanto Wrinkle Recovery Tester.

Sheets sampled for this study were those which had been used at the University of North Carolina at Greensboro, as part of Phase II of Southern Regional Research Project SM-18. A total of 240 sheets which had been withdrawn from the project following 0, 5, 15, 30, 45, and 60 periods of use and laundering and following 0, 5, 15, 30, 45, and 60 periods of laundering only were used for testing. Measurements of both warp and filling yarns were obtained in the tests for yarn number, yarn diameter and wrinkle recovery. An analysis of variance, which was the statistical procedure developed for Southern Regional Project SM-18 was used to analyze the data and to determine the F ratios. Correlation coefficients were computed to determine relationship between yarn characteristics and wrinkle recovery.

I. DISCUSSION OF FINDINGS RELATED TO YARN NUMBER

Yarn number for cotton in the English System is the number of 840 yard hanks in one pound. The number indicates the size of the yarn; the higher the yarn number, the smaller the yarn. The project specification for spinning the cotton into yarn was for 22's which represented 22 hanks per pound in both warp and filling yarns.

Laundered Only Cottons

Changes in yarn number of cottons varying in fiber length and strength following laundering are presented in Table II. These changes are presented graphically in Figure 2. Yarn numbers for each cotton at all periods of testing are presented in Appendix A.

The mean yarn number of the laundered only cottons indicated that the yarns became progressively smaller in size at each period of laundering. At the control period the yarn number of the short staple cottons was 23.2 in the warp and 22.6 in the filling. At the sixtieth period the yarn number of the short staple cottons had increased to 25.2 in the warp and 24.9 in the filling, a percentage increase of 8.6 and 10.2 per cent respectively. The long staple cottons increased in yarn number from 22.9 to 25.1 in the warp yarns and from 22.1 to 24.7 in the filling yarns, an increase of 9.6 per cent and 11.8 per cent respectively.

TABLE II

CHANGES IN YARN NUMBER OF COTTONS VARYING IN FIBER LENGTH AND STRENGTH FOLLOWING LAUNDERING

Testing periods	Fiber Properties							
	Short staple		Long staple		Low strength		High strength	
	Yarn number	Per cent change	Yarn number	Per cent change	Yarn number	Per cent change	Yarn number	Per cent change
Zero								
Warp	23.2	--	22.9	--	23.0	--	23.2	--
Filling	22.6	--	22.1	--	22.4	--	22.4	--
Five								
Warp	23.5	+1.2	23.6	+3.0	23.5	+2.2	23.6	+1.7
Filling	22.8	+0.8	22.4	+1.4	22.6	+0.8	22.6	+0.8
Fifteen								
Warp	23.8	+2.5	24.3	+6.1	23.9	+3.9	24.2	+4.3
Filling	23.1	+2.2	23.7	+7.2	23.4	+4.5	23.4	+4.5
Thirty								
Warp	24.4	+5.1	24.4	+6.6	24.7	+7.4	24.1	+3.9
Filling	24.1	+6.6	23.4	+5.9	23.8	+6.2	23.7	+5.8
Forty-five								
Warp	25.4	+9.5	24.8	+8.3	25.4	+10.4	24.7	+6.5
Filling	24.5	+8.4	24.1	+9.0	24.4	+8.9	24.2	+8.0
Sixty								
Warp	25.2	+8.6	25.1	+9.6	25.2	+9.6	25.1	+8.2
Filling	24.9	+10.2	24.7	+11.8	25.0	+11.6	24.5	+9.4

*Yarn number as measured by the Suter Yarn Numbering Balance.

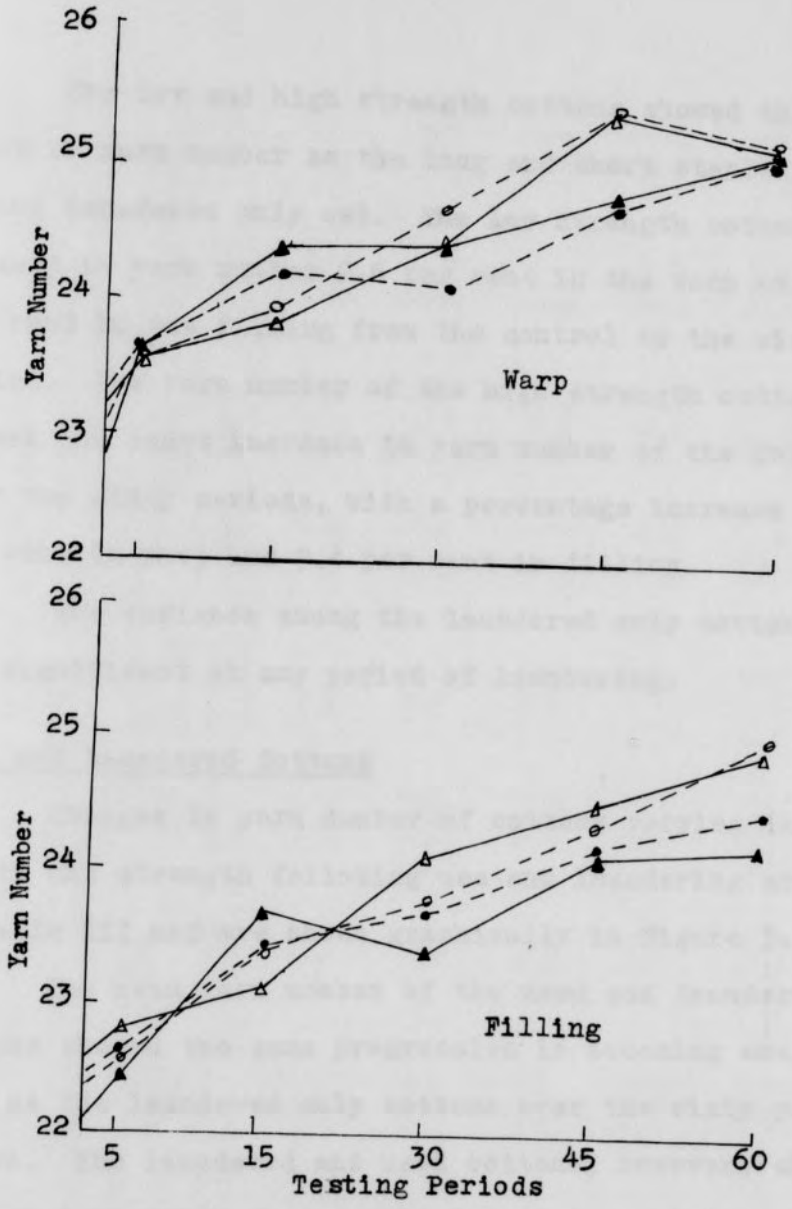

FIGURE 2

MEAN YARN NUMBER OF LAUNDERED ONLY COTTONS

Key

- Short staple
- Long staple
- Low strength
- High strength

The low and high strength cottons showed the same trend in yarn number as the long and short staple cottons in the laundered only set. The low strength cottons increased in yarn number 9.6 per cent in the warp and 11.6 per cent in the filling from the control to the sixtieth period. The yarn number of the high strength cottons showed the least increase in yarn number of the four cottons, over the sixty periods, with a percentage increase of 8.2 per cent in warp and 9.4 per cent in filling.

The variance among the laundered only cottons was not significant at any period of laundering.

Used and Laundered Cottons

Changes in yarn number of cottons varying in fiber length and strength following use and laundering are presented in Table III and are shown graphically in Figure 3.

The mean yarn number of the used and laundered cottons showed the same progression in becoming smaller in size as the laundered only cottons over the sixty periods of use. The laundered and used cottons, however, showed a greater percentage change over the sixty periods. The short staple cottons increased least in yarn number in the laundered and used set showing a 12.1 per cent change in warp and a 15.0 per cent change in filling. An increase of 12.2 per cent in the warp direction and 16.7 per cent

TABLE III

CHANGES IN YARN NUMBER OF COTTONS VARYING IN FIBER LENGTH AND STRENGTH FOLLOWING USE AND LAUNDERING

Testing periods	Fiber Properties							
	Short staple		Long staple		Low strength		High strength	
	Yarn number*	Per cent change	Yarn number	Per cent change	Yarn number	Per cent change	Yarn number	Per cent change
Zero								
Warp	23.2	--	22.9	--	23.0	--	23.2	--
Filling	22.6	--	22.1	--	22.4	--	22.4	--
Five								
Warp	23.5	+1.2	23.8	+3.9	23.6	+2.6	23.7	+2.2
Filling	23.1	+2.2	22.4	+4.1	22.8	+1.8	22.7	+1.3
Fifteen								
Warp	24.1	+3.9	24.3	+6.1	24.5	+6.5	23.9	+3.0
Filling	23.8	+5.3	23.1	+4.5	23.5	+4.9	23.4	+4.5
Thirty								
Warp	24.5	+5.6	24.2	+5.7	24.9	+8.3	23.9	+3.0
Filling	24.0	+6.2	23.8	+7.7	23.8	+6.2	24.0	+7.1
Forty-five								
Warp	25.4	+9.5	25.2	+10.0	25.4	+10.4	25.2	+8.6
Filling	25.3	+11.9	24.1	+9.0	24.7	+10.3	24.8	+10.7
Sixty								
Warp	26.0	+12.1	25.7	+12.2	25.9	+12.6	25.8	+11.2
Filling	26.0	+15.0	25.8	+16.7	25.8	+15.2	26.0	+16.0

*Yarn number as measured by the Suter Yarn Numbering Balance.

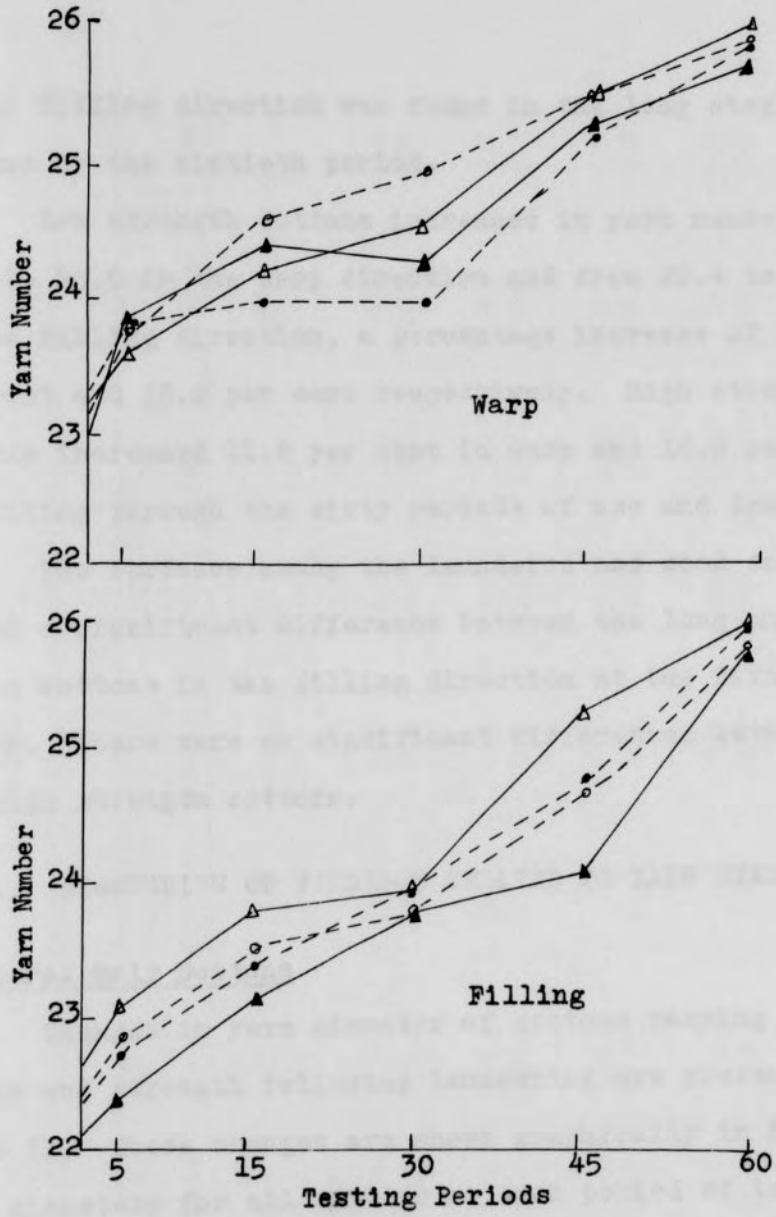

FIGURE 3

MEAN YARN NUMBER OF USED AND LAUNDERED COTTONS

Key

—Δ— Short staple
—▲— Long Staple
—○— Low strength
—●— High strength

in the filling direction was found in the long staple cottons by the sixtieth period.

Low strength cottons increased in yarn number from 23.0 to 25.9 in the warp direction and from 22.4 to 25.8 in the filling direction, a percentage increase of 12.6 per cent and 15.2 per cent respectively. High strength cottons increased 11.2 per cent in warp and 16.0 per cent in filling through the sixty periods of use and laundering.

The variance among the laundered and used cottons showed a significant difference between the long and short staple cottons in the filling direction at the fifth period. There were no significant differences between low and high strength cottons.

II. DISCUSSION OF FINDINGS RELATED TO YARN DIAMETER

Laundered Only Cottons

Changes in yarn diameter of cottons varying in fiber length and strength following laundering are presented in Table IV. These changes are shown graphically in Figure 4. Yarn diameters for all cottons at each period of testing are presented in Appendix B.

Results of the tests for yarn diameter of the laundered only cottons indicated considerable variation in yarn diameter. There was, however, a general decrease in yarn diameters throughout the testing periods. The yarn

TABLE IV

CHANGES IN YARN DIAMETER OF COTTONS VARYING IN FIBER LENGTHS AND STRENGTH FOLLOWING LAUNDERING

Testing periods	Fiber Properties							
	Short staple		Long staple		Low strength		High strength	
	Yarn diameter*	Per cent change	Yarn diameter	Per cent change	Yarn diameter	Per cent change	Yarn diameter	Per cent change
Zero								
Warp	10.4	—	10.5	—	10.7	—	10.2	—
Filling	11.3	—	10.6	—	11.3	—	10.6	—
Five								
Warp	9.8	-5.8	9.9	-9.4	9.8	-8.4	9.9	-2.9
Filling	10.3	-8.8	10.6	-0.0	10.2	-9.7	10.7	+0.9
Fifteen								
Warp	9.8	-5.8	10.0	-4.8	9.9	-7.5	9.9	-2.9
Filling	9.9	-12.4	10.0	-5.7	10.0	-11.5	10.0	-5.7
Thirty								
Warp	9.6	-7.7	9.6	-8.6	9.6	-10.3	9.6	-5.9
Filling	10.5	-7.1	10.5	-0.9	10.6	-6.2	10.3	-2.8
Forty-five								
Warp	9.7	-6.7	9.9	-5.7	9.9	-7.5	9.6	-5.9
Filling	10.3	-8.8	10.5	-0.5	10.1	-10.6	10.7	+0.9
Sixty								
Warp	10.1	-2.9	9.3	-11.4	9.5	-11.2	9.8	-3.9
Filling	10.1	-10.6	9.9	-6.6	9.8	-13.3	10.1	-4.7

*Yarn diameter is expressed in millimeters as measured by the Visopan Microprojector 50X Magnification.

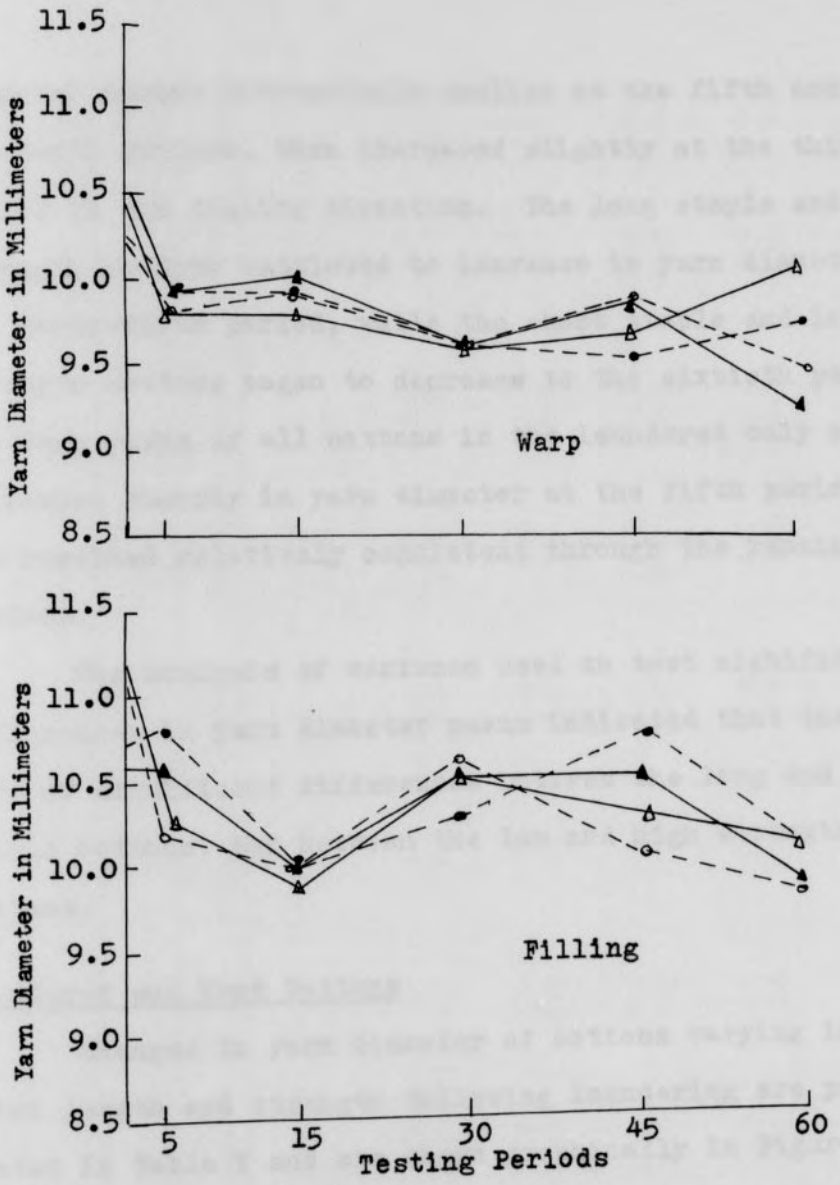

FIGURE 4

MEAN YARN DIAMETER OF LAUNDERED ONLY COTTONS

Key

—△— Short staple
—▲— Long staple
-⊖- Low strength
-●- High strength

diameter became increasingly smaller at the fifth and fifteenth periods, then increased slightly at the thirtieth period in the filling direction. The long staple and high strength cottons continued to increase in yarn diameter to the forty-fifth period, while the short staple and low strength cottons began to decrease to the sixtieth period. The warp yarns of all cottons in the laundered only set decreased sharply in yarn diameter at the fifth period, but remained relatively consistent through the remaining periods.

The analysis of variance used to test significant differences in yarn diameter means indicated that there were no significant differences between the long and short staple cottons, nor between the low and high strength cottons.

Laundered and Used Cottons

Changes in yarn diameter of cottons varying in fiber length and strength following laundering are presented in Table V and are shown graphically in Figure 5.

Results of tests on the laundered and used cottons indicated that the yarn diameter of all cottons decreased sharply to the fifth period in both warp and filling directions. In the warp direction all cottons increased from the fifth period to the thirtieth period, then again

TABLE V

CHANGES IN YARN DIAMETER OF COTTONS VARYING IN FIBER LENGTH AND STRENGTH FOLLOWING USE AND LAUNDERING

Testing Periods	Fiber Properties							
	Short staple		Long staple		Low strength		High strength	
	Yarn diameter*	Per cent change	Yarn diameter	Per cent change	Yarn diameter	Per cent change	Yarn diameter	Per cent change
Zero								
Warp	10.4	--	10.5	--	10.7	--	10.2	--
Filling	11.3	--	10.6	--	11.3	--	10.6	--
Five								
Warp	9.8	-5.8	9.3	-11.4	9.8	-8.4	9.3	-8.8
Filling	10.2	-9.7	9.7	-8.5	10.1	-10.6	9.9	-8.5
Fifteen								
Warp	9.8	-5.8	9.4	-10.5	9.5	-11.2	9.8	-3.9
Filling	10.0	-11.5	9.7	-8.5	9.8	-13.3	9.9	-3.8
Thirty								
Warp	10.4	-0.0	10.1	-3.8	10.2	-4.7	10.2	0.0
Filling	10.8	-4.4	10.0	-5.7	10.5	-7.1	10.3	-2.8
Forty-five								
Warp	9.7	-6.7	9.1	-13.3	9.3	-13.1	9.5	-6.9
Filling	10.1	-10.6	10.2	-3.8	9.8	-13.3	10.4	-6.6
Sixty								
Warp	8.7	-16.3	8.9	-15.2	8.8	-17.8	8.7	-14.7
Filling	9.7	-14.2	9.0	-15.1	9.6	-15.0	9.1	-14.2

*Yarn diameter is expressed in millimeters as measured by the Visopan Microprojector-50X Magnification.

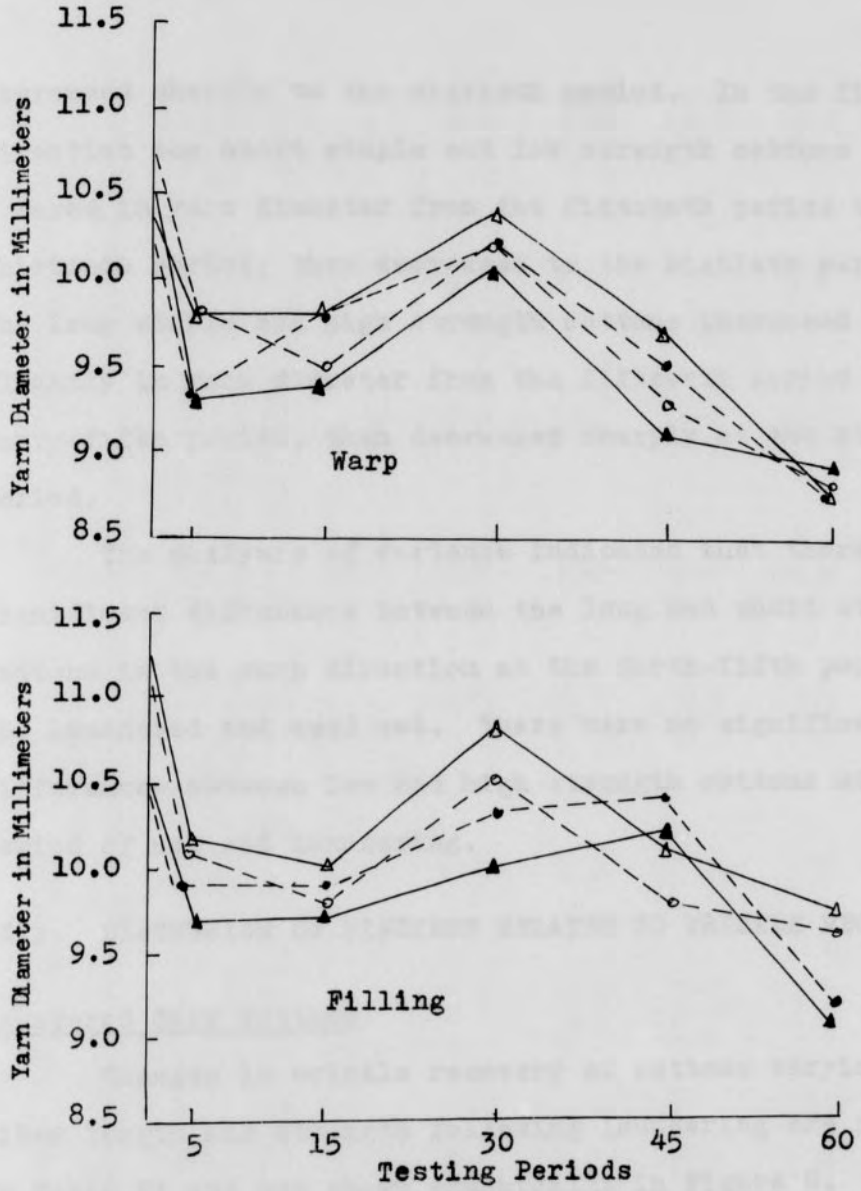

FIGURE 5

MEAN YARN DIAMETER OF USED AND LAUNDERED COTTONS

Key
- Short staple
- Long staple
- Low strength
- High strength

decreased sharply to the sixtieth period. In the filling direction the short staple and low strength cottons increased in yarn diameter from the fifteenth period to the thirtieth period, then decreased to the sixtieth period. The long staple and high strength cottons increased slightly in yarn diameter from the fifteenth period to the forty-fifth period, then decreased sharply at the sixtieth period.

The analysis of variance indicated that there was a significant difference between the long and short staple cottons in the warp direction at the forth-fifth period in the laundered and used set. There were no significant differences between low and high strength cottons at any period of use and laundering.

III. DISCUSSION OF FINDINGS RELATED TO WRINKLE RECOVERY

Laundered Only Cottons

Changes in wrinkle recovery of cottons varying in fiber length and strength following laundering are presented in Table VI and are shown graphically in Figure 6. Wrinkle recovery data for each cotton type at all periods of testing are presented in Appendix C.

The mean wrinkle recovery of the laundered only cottons indicated that the wrinkle recovery of all cottons

TABLE VI

CHANGES IN WRINKLE RECOVERY OF COTTONS VARYING IN FIBER LENGTH AND STRENGTH FOLLOWING LAUNDERING

Testing Periods	Fiber Properties							
	Short staple		Long staple		Low strength		High strength	
	Wrinkle recovery*	Per cent change	Wrinkle recovery	Per cent change	Wrinkle recovery	Per cent change	Wrinkle recovery	Per cent change
Zero								
Warp	76	—	78	--	75	--	78	--
Filling	78	—	79	--	78	--	79	—
Five								
Warp	78	+ 2.6	79	+ 1.3	78	+ 4.0	80	+ 2.6
Filling	79	+ 1.3	82	+ 3.8	82	+ 5.1	79	0.0
Fifteen								
Warp	91	+19.7	94	+20.5	93	+24.0	93	+19.2
Filling	93	+19.2	94	+19.0	93	+19.2	94	+18.9
Thirty								
Warp	82	+ 7.9	81	+ 3.8	82	+ 9.3	82	+ 5.1
Filling	84	+ 7.7	84	+ 3.8	84	+ 7.7	85	+ 7.6
Forty-five								
Warp	87	+14.5	85	+ 9.0	86	+14.7	86	+10.2
Filling	88	+12.8	86	+ 8.9	87	+11.5	86	+ 8.9
Sixty								
Warp	76	0.0	75	- 3.8	75	0.0	76	- 2.6
Filling	78	0.0	79	0.0	79	+1.3	79	0.0

*Wrinkle recovery is expressed in degrees of recovery as measured by the Monsanto Wrinkle Recovery Tester.

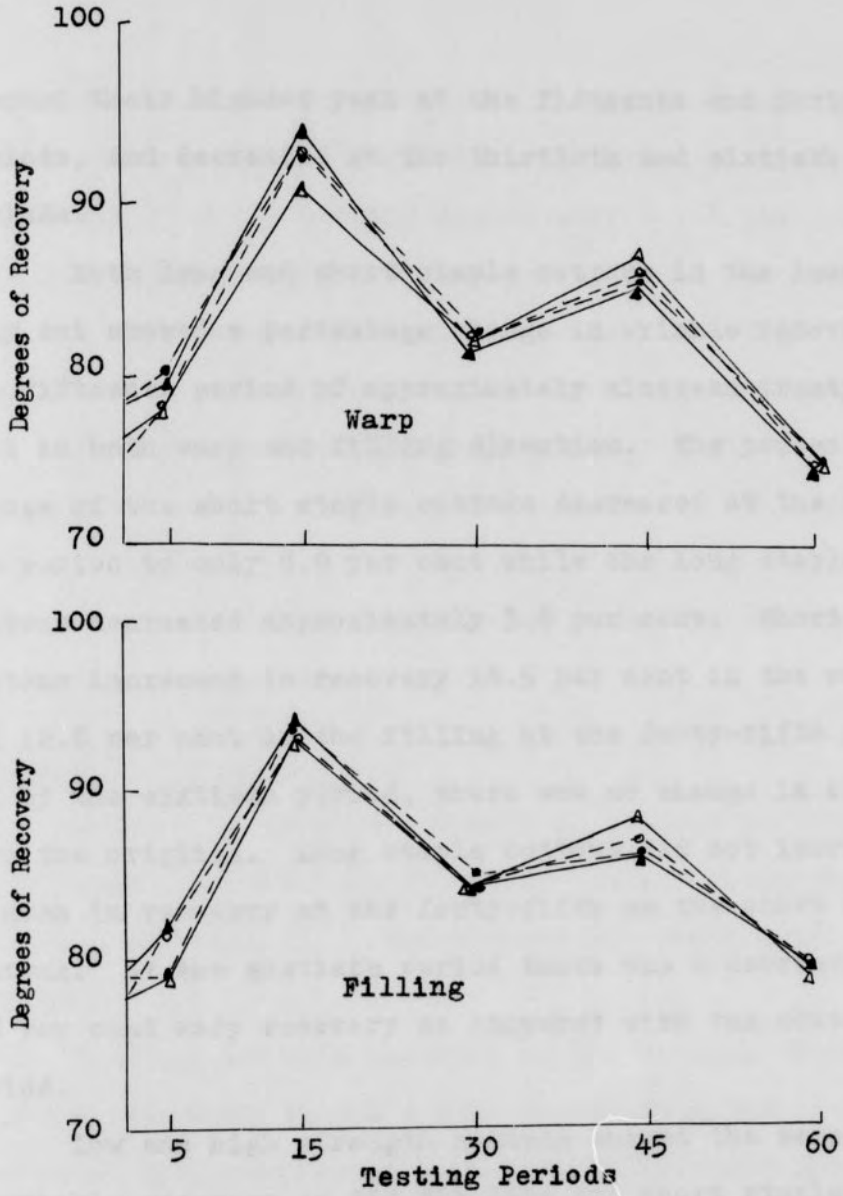

FIGURE 6

MEAN WRINKLE RECOVERY OF LAUNDERED ONLY COTTONS

Key

—△— Short staple
—▲— Long staple
—○— Low strength
—●— High strength

reached their highest peak at the fifteenth and forty-fifth periods, and decreased at the thirtieth and sixtieth periods.

Both long and short staple cottons in the laundered only set showed a percentage change in wrinkle recovery at the fifteenth period of approximately nineteen-twenty per cent in both warp and filling direction. The percentage change of the short staple cottons decreased at the thirtieth period to only 8.0 per cent while the long staple cottons decreased approximately 3.8 per cent. Short staple cottons increased in recovery 14.5 per cent in the warp and 12.8 per cent in the filling at the forty-fifth period, but by the sixtieth period, there was no change in recovery from the original. Long staple cottons did not increase as much in recovery at the forty-fifth as the short staple cottons. At the sixtieth period there was a decrease of 3.8 per cent warp recovery as compared with the control period.

Low and high strength cottons showed the same trend in wrinkle recovery as did the long and short staple cottons. By the fifteenth period the low strength cottons showed a percentage change of twenty-four per cent in the warp and 19.2 per cent in the filling from the original, while the high strength cottons showed a percentage change of approximately 19 per cent in both directions. Both types of

cotton decreased in recovery at the thirtieth period and increased again at the forty-fifth period. At the sixtieth period low strength cottons showed only a 1.3 per cent change from the original in the filling, and no change from the original in the warp direction. The high strength cotton showed a minus recovery at the sixtieth period in warp and no change from the original in the filling.

The analysis of variance used to test the significance of variance of wrinkle recovery means indicated that there was no significant difference among the cottons in the laundered only set.

Used and Laundered Cottons

Changes in wrinkle recovery of cottons varying in fiber length and strength following use and laundering are presented in Table VII. The changes are shown graphically in Figure 7.

The mean wrinkle recovery of the cottons which were used and laundered showed slight change from the laundered only set. Long staple and high strength cottons showed the greatest recovery at the fifth and fifteenth periods. Short staple and low strength cottons showed the greatest change from the original at the fifteenth and forty-fifth periods. The laundered and used cottons generally showed greater recovery at all periods than the cottons in the laundered only set.

TABLE VII

CHANGES IN WRINKLE RECOVERY OF COTTONS VARYING IN FIBER LENGTH AND STRENGTH FOLLOWING USE AND LAUNDERING

Testing Periods	Fiber Properties							
	Short staple		Long staple		Low strength		High strength	
	Wrinkle recovery*	Per cent change	Wrinkle recovery	Per cent change	Wrinkle recovery	Per cent change	Wrinkle recovery	Per cent change
Zero								
Warp	76	--	78	--	75	--	78	--
Filling	78	--	79	--	78	--	79	--
Five								
Warp	89	+17.1	96	+23.1	90	+20.0	95	+21.8
Filling	87	+11.5	96	+21.5	89	+14.1	94	+19.0
Fifteen								
Warp	90	+18.4	92	+17.9	91	+21.3	91	+16.7
Filling	91	+16.7	89	+12.6	90	+15.4	90	+13.9
Thirty								
Warp	87	+14.5	87	+11.5	88	+17.3	87	+11.5
Filling	90	+15.4	88	+11.4	90	+15.4	88	+11.4
Forty-five								
Warp	92	+21.0	90	+15.4	92	+22.7	90	+15.4
Filling	93	+19.2	91	+15.2	93	+19.2	91	+15.2
Sixty								
Warp	84	+10.5	83	+6.4	83	+10.7	85	+9.0
Filling	87	+11.5	87	+10.1	87	+11.5	87	+10.1

*Wrinkle recovery is expressed in degrees of recovery as measured by the Monsanto Wrinkle Recovery Tester.

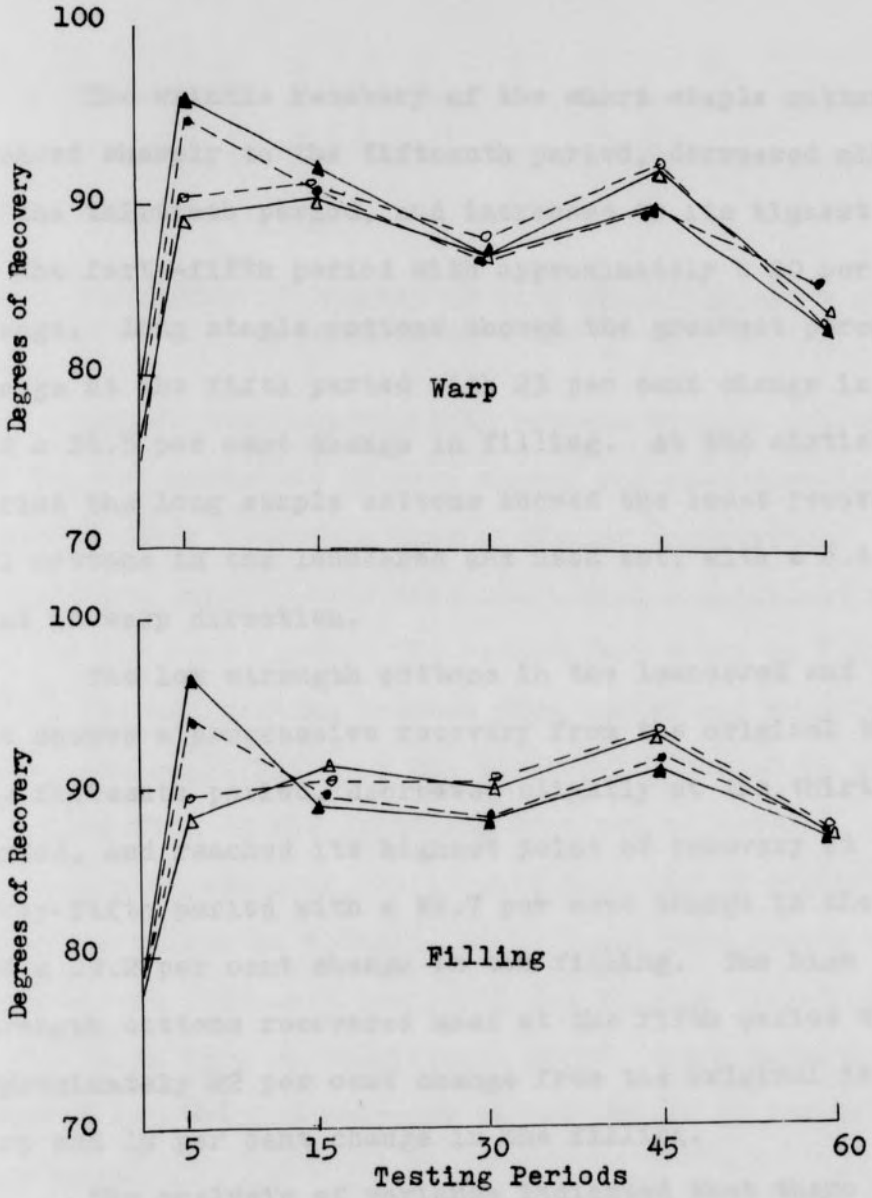

FIGURE 7

MEAN WRINKLE RECOVERY OF USED AND LAUNDERED COTTONS

Key
Short staple
Long staple
Low strength
High strength

The wrinkle recovery of the short staple cottons increased sharply to the fifteenth period, decreased slightly at the thirtieth period, and increased to its highest point at the forty-fifth period with approximately a 20 per cent change. Long staple cottons showed the greatest percentage change at the fifth period with 23 per cent change in warp and a 21.5 per cent change in filling. At the sixtieth period the long staple cottons showed the least recovery of all cottons in the laundered and used set, with a 6.4 per cent in warp direction.

The low strength cottons in the laundered and used set showed a progressive recovery from the original through the fifteenth period, decreased slightly at the thirtieth period, and reached its highest point of recovery at the forty-fifth period with a 22.7 per cent change in the warp and a 19.2 per cent change in the filling. The high strength cottons recovered most at the fifth period with approximately 22 per cent change from the original in the warp and 19 per cent change in the filling.

The analysis of variance indicated that there were significant differences in wrinkle recovery of the cottons in the laundered and used set. There was a significant difference between the long and short staple cottons in the filling direction at the fifteenth period. At the

forty-fifth period in the same set, there was a significant difference between the low and high strength cottons in the filling direction.

IV. RELATION OF CHANGES IN YARN CHARACTERISTICS TO WRINKLE RECOVERY

Correlation coefficients between wrinkle recovery and the two variables of yarn number and yarn diameter were computed using Pearson's Product Moment Correlation. The correlation coefficients were considered significant at the .05 per cent level. The results are shown in Table VIII.

The correlation between yarn number and wrinkle recovery was significant at the forty-fifth period in the warp direction of the laundered only set of cottons. In the laundered and used set of cottons a highly significant correlation between wrinkle recovery and yarn number was found at the fifteenth period in the filling direction.

There were no significant correlations between yarn diameter and wrinkle recovery at any period of use or laundering.

TABLE VIII

CORRELATION COEFFICIENTS BETWEEN WRINKLE RECOVERY AND YARN NUMBER AND YARN DIAMETER

Cottons	Testing Periods											
	0		5		15		30		45		60	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Laundered only												
Yarn number and wrinkle recovery	.07	-.66	.44	-.61	.50	.44	.37	.01	-.73*	.07	.27	-.08
Yarn diameter and wrinkle recovery	.00	.31	.05	.15	.30	-.61	-.44	.53	.67	.00	.59	.14
Laundered and used												
Yarn number and wrinkle recovery	.07	-.66	.01	-.47	.34	.86**	.33	.02	.01	.35	.03	.67
Yarn diameter and wrinkle recovery	.00	-.23	-.25	-.09	-.51	.42	.27	.27	.27	-.48	-.23	-.46

*Significant at .05 .707.

**Significant at .01 .834.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

I. SUMMARY

Cotton, one of the chief agricultural products of the South, has been subject to considerable investigation by those interested in keeping the fiber a prominent part of the textile industry. Extensive research has been concerned with the fiber properties of raw cotton. Little experimentation, however, has been directed toward the relation between cotton fiber properties and the serviceability of cotton products in consumer use. To meet this need a cooperative research project was undertaken by the Agricultural Experiment Stations of the Southern Region under the sponsorship of the United States Department of Agriculture.

Southern Regional Research Project SM-18 was designed to investigate the relation between certain fiber properties and the performance characteristics of untreated cotton sheeting. Fiber length and fiber strength were designated as the specific fiber properties to be studied in the second phase of the project. To determine the relationship

between these variables and the end-product performance, eight bales of experimental cotton, selected to measure two levels of length (long and short staple), and two levels of strength (low and high strength), were manufactured into type 140 muslin sheeting. After distribution to four Southern universities, the sheets were divided into two groups. One group was used in women's dormitories and laundered weekly by a commercial laundry. The second group was not used in the dormitories, but was laundered weekly following the same schedule as the used sheets. Sheets serviced at the University of North Carolina at Greensboro following all periods of use and laundering and all periods of laundering only provided data for this study.

Experimentation completed earlier in the project using the Monsanto method for testing wrinkle recovery indicated considerable variation between sheeting made from fibers of varied properties of length and strength. It seemed that some of this variation might be caused by changes in yarn structure.

The specific objectives of this study were:

1. To determine the yarn characteristics of experimental cotton sheeting made of cottons with two levels of strength as measured by yarn number and yarn diameter.

2. To determine the wrinkle recovery of experimental cotton sheeting made from cottons with two levels of length and two levels of strength.

3. To determine the relationship between yarn characteristics and the wrinkle recovery of the selected cotton sheeting.

The study was designed to test the following hypotheses:

1. There is no difference in yarn number of cottons of varying properties of length and strength before and after (1) use and laundering and (2) laundering only.

2. There is no difference in yarn diameter of cottons of varying properties of length and strength before and after (1) use and laundering and (2) laundering only.

3. There is no difference in wrinkle recovery of sheetings made from cottons of varying properties of length and strength before and after (1) use and laundering and (2) laundering only.

4. There is no correlation between yarn characteristics studied and wrinkle recovery.

The laboratory analysis of the samples measured changes in yarn structure and wrinkle recovery. Changes in yarn number, the weight of hanks per pound, were measured by the Suter Yarn Numbering Balance. Eight samples of warp yarns and eight samples of filling yarns were weighed for each sheet, a total of sixteen measurements in both warp and filling directions for each cotton type at all periods.

Changes in yarn diameter were measured in millimeters by the Visopan Microprojector. Three measurements for each of ten sample yarns in both warp and filling direction were determined for all sheets, a total of sixty measurements in each direction for each cotton type at all periods.

Changes in wrinkle recovery were measured in the degrees of recovery by the Monsanto Wrinkle Recovery Tester. Six fabric samples cut from both warp and filling direction were measured for wrinkle recovery, a total of twelve measurements in each direction for each cotton type at all periods.

An analysis of variance was the statistical procedure used to determine the significance of differences between the cottons of varying properties of length and strength as measured by yarn number, yarn diameter, and wrinkle recovery after 0, 5, 15, 30, 45, and 60 periods of use and laundering and after 0, 5, 15, 30, 45, and 60 periods of laundering only. Findings were considered significant at the .05 per cent level. Coefficients of correlation between wrinkle recovery and corresponding yarn number and yarn diameter were determined using Pearson's Product Moment Correlation.

Yarn Number

The progressive rise in yarn number indicated that yarns of all cottons became increasingly smaller in size at each period, with the yarns in the laundered and used set having more weight loss than those in the laundered only set. At the sixtieth period of use and laundering the yarns of all four cotton types had decreased in size.

These decreases ranged from approximately 12 - 17 per cent. The decrease in yarn size of the four cotton types in the laundered only set ranged from approximately 8 -12 per cent.

Differences in yarn number among all cottons were not generally significant. There were no significant differences among the cottons in the laundered only set in any period. Among the laundered and used set there was a significant difference between the long and short staple cottons in the filling at the fifth period.

Yarn Diameter

The yarn diameter of all cottons showed considerable variation at all periods. The yarns generally decreased in diameter with a larger decrease among the yarns in the laundered and used set. In both sets the yarns made from the high strength cottons generally decreased less in yarn diameter, while the yarns made from the low strength cottons generally decreased more than the other yarns.

Differences in yarn diameter among all cottons were not generally significant. There were no significant differences among the cottons in the laundered only set at any period. There was a significant difference between the long and short staple cottons in the warp direction at the forty-fifth period of use and laundering.

Wrinkle Recovery

The wrinkle recovery of all cottons showed variation between those in the laundered and used set and those in the laundered only set. The cottons in the laundered and used set generally showed greater recovery at all intervals than the cottons in the laundered only set.

The mean wrinkle recovery of the laundered only cottons indicated that all cottons recovered most at the fifteenth and forty-fifth periods, and showed least recovery at the thirtieth and sixtieth periods. Low strength cottons and short staple cottons tended to show greater recovery at all intervals than did the high strength and long staple cottons.

The mean wrinkle recovery of the cottons in the used and laundered set showed some changes from the laundered only set. Long staple and high strength cottons showed the greatest recovery at the fifth and fifteenth periods, while short staple and low strength cottons recovered more at the fifteenth and forty-fifth periods.

Differences in wrinkle recovery among all cottons were not generally significant. There were no significant differences among the cottons in the laundered only set at any period. Among the laundered and used set, there were significant differences between the long and short staple cottons in the filling at the fifteenth period and between

the low and high strength cottons in the filling at the forty-fifth period.

Relation of Changes in Yarn Characteristics to Wrinkle Recovery

Correlation coefficients between wrinkle recovery and yarn number and yarn diameter were computed using Pearson's Product Moment Correlation. Two significant correlations were found between yarn number and wrinkle recovery. At the forty-fifth period a significant correlation was found in the warp direction in the laundered only set of cottons. A highly significant correlation was found between yarn number and wrinkle recovery at the fifteenth period in the filling in the laundered and used set of cottons.

Though there were no other significant correlations, positive and negative correlations were computed for both sets of relationships. In the yarn number-wrinkle recovery relationship there were more positive correlations than negative correlations, possibly indicating that the weight per unit length of yarn does affect the wrinkle recovery of a fabric. In the relationship between yarn diameter and wrinkle recovery, approximately one-half of the coefficients were positive and one-half were negative, indicating little relationship between yarn diameter and wrinkle recovery.

II. CONCLUSIONS

The results of this study indicate the following conclusions:

1. Yarns became progressively smaller in size after use and laundering and after laundering only as indicated by yarn number and yarn diameter.

2. The yarn size of the cottons in the laundered and used set decreased more than those in the laundered only set as indicated by yarn number and yarn diameter.

3. The wrinkle recovery of the sheets in the laundered and used set was greater than the wrinkle recovery of sheets in the laundered only set.

4. There were generally no significant differences in yarn number between long and short staple cottons and low and high strength cottons after use and laundering and after laundering only.

5. There were generally no significant differences in yarn diameter between long and short staple cottons after use and laundering and after laundering only.

6. There were generally no significant differences in wrinkle recovery between long and short staple cottons and low and high strength cottons after useand laundering and after laundering only.

7. Changes in yarn characteristics were not closely related to changes in wrinkle recovery of the sheeting.

III. RECOMMENDATIONS FOR FURTHER STUDY

Further study is needed to relate yarn characteristics to wrinkle recovery. The following recommendations are made for further study:

1. Compare yarn characteristics to wrinkle recovery as determined by the Celanese method of testing wrinkle recovery.

2. Compare yarn characteristics to other physical properties of textile fabrics such as tensile strength, elongation, tear strength and fluidity.

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APPENDIX A

APPENDIX A

MEAN YARN NUMBER OF COTTONS AFTER USE AND LAUNDERING AND AFTER LAUNDERING ONLY

Cottons	Testing Periods											
	0		5		15		30		45		60	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Laundered Only												
One	23.4	23.2	22.3	22.8	23.9	23.3	25.4	24.9	25.8	25.1	25.6	25.4
Two	23.4	22.3	24.4	23.0	23.4	22.8	23.8	24.0	26.0	24.4	25.4	25.5
Three	23.0	22.3	23.0	22.4	24.2	22.6	24.1	23.6	24.2	24.3	24.8	24.0
Four	23.5	21.7	24.3	23.2	23.7	23.6	24.4	23.9	25.4	24.1	24.8	24.5
Five	22.5	22.0	24.0	22.4	24.6	24.2	25.0	22.9	24.7	23.0	24.8	25.1
Six	22.9	22.2	23.2	22.4	23.6	23.2	24.4	23.4	25.2	24.0	25.1	24.1
Seven	22.3	22.2	23.4	22.6	23.6	23.4	23.2	23.5	24.0	24.0	25.0	24.2
Eight	23.8	22.4	23.5	22.3	25.4	24.2	24.8	24.0	25.2	24.4	25.6	25.4
Used and Laundered												
One	23.4	23.2	23.7	23.6	24.0	24.2	25.3	25.1	25.0	25.4	25.6	26.5
Two	23.4	22.3	23.7	23.2	25.2	23.7	24.9	23.2	26.2	25.7	26.6	25.3
Three	23.0	22.3	23.0	22.0	23.5	23.3	23.7	24.2	24.5	24.5	25.7	25.4
Four	23.5	21.7	23.6	22.7	23.8	23.9	24.2	23.8	25.8	25.7	26.3	26.8
Five	22.5	22.0	24.5	22.4	24.5	23.8	24.7	23.5	25.5	23.7	25.9	26.0
Six	22.9	22.2	22.5	22.0	24.4	22.4	24.6	23.5	25.1	23.7	25.6	25.4
Seven	22.3	22.2	23.4	22.9	23.4	22.7	22.3	24.0	24.4	23.9	25.0	25.8
Eight	23.8	22.4	24.9	22.4	24.7	23.6	25.4	24.1	25.7	25.2	26.2	25.5

APPENDIX B

APPENDIX B

MEAN YARN DIAMETER EXPRESSED IN MILLIMETERS OF COTTONS AFTER USE AND LAUNDERING AND AFTER LAUNDERING ONLY

Cottons	Testing Periods											
	0		5		15		30		45		60	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Laundered Only												
One	10.2	11.2	9.8	9.4	9.4	10.0	9.4	10.1	10.0	9.5	10.4	9.7
Two	11.5	12.1	9.7	10.7	10.0	9.4	10.1	10.8	9.4	11.0	9.6	9.3
Three	9.7	11.2	9.8	10.8	9.4	10.0	9.8	10.4	10.0	9.8	9.8	10.4
Four	10.4	10.5	10.0	10.2	10.2	10.2	9.2	10.6	9.3	11.0	10.5	11.0
Five	10.5	10.6	9.8	10.5	10.3	9.7	9.5	10.4	10.2	9.6	8.8	10.0
Six	10.5	11.2	9.9	10.1	10.0	10.6	9.4	11.2	10.1	10.4	9.2	10.3
Seven	10.2	10.2	9.4	10.2	10.2	10.2	10.0	9.5	9.8	11.2	9.7	9.6
Eight	10.5	10.4	10.5	11.6	9.7	9.5	9.8	10.8	9.4	10.7	9.4	9.5
Used and Laundered												
One	10.2	11.2	10.2	10.3	9.4	10.0	10.1	10.7	9.3	9.5	8.8	9.4
Two	11.5	12.1	10.1	10.6	9.8	10.0	10.4	11.0	9.6	9.8	8.9	10.3
Three	9.7	11.2	9.2	9.9	10.2	9.8	10.7	10.6	10.0	11.0	8.1	10.1
Four	10.4	10.5	9.9	10.1	10.7	9.9	10.2	10.5	9.9	10.0	9.0	8.9
Five	10.5	10.6	9.1	9.2	9.3	9.4	10.1	10.1	9.4	10.3	8.8	9.2
Six	10.5	11.2	9.9	10.3	9.7	10.0	10.3	10.1	8.8	9.6	8.8	9.4
Seven	10.2	10.2	8.8	9.4	9.2	9.6	9.9	9.7	9.2	10.1	8.8	8.8
Eight	10.5	10.4	9.3	10.1	9.9	10.0	10.1	10.2	9.0	10.7	9.1	8.6

APPENDIX C

APPENDIX C

MEAN WRINKLE RECOVERY EXPRESSED IN DEGREES OF THE ANGLE OF RECOVERY OF COTTONS AFTER USE AND LAUNDERING AND AFTER LAUNDERING ONLY

Cottons	Testing Periods											
	0		5		15		30		45		60	
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Laundered Only												
One	70	75	76	82	90	92	82	85	87	87	77	80
Two	76	77	80	79	92	92	83	82	88	88	74	77
Three	78	80	80	80	92	96	80	84	86	86	76	88
Four	79	80	78	77	91	92	84	86	88	90	78	78
Five	76	81	81	84	94	96	80	86	84	87	74	80
Six	78	80	74	83	95	90	84	85	86	86	75	80
Seven	77	76	80	76	94	92	78	80	85	84	74	78
Eight	80	80	81	83	96	98	83	85	86	85	78	80
Used and Laundered												
One	70	75	88	89	92	92	87	90	93	95	85	88
Two	76	77	88	84	92	91	88	91	94	95	81	85
Three	78	80	90	88	92	90	86	88	92	93	86	85
Four	79	80	91	88	87	92	88	90	90	91	85	89
Five	76	81	85	86	93	90	84	87	91	91	83	87
Six	78	80	98	98	89	89	91	91	91	93	83	88
Seven	77	76	97	98	91	88	85	85	91	90	82	85
Eight	80	80	103	100	94	90	87	97	89	90	86	87