THE EFFECT OF A FABRIC SOFTENER

ON THE SURFACE APPEARANCE OF

WASH-WEAR COTTON FABRICS

by

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A Thesis Submitted to
the Faculty of the Graduate School at
The Woman's College of the University of North Carolina
in Partial Fulfillment
of the Requirements for the Degree
Master of Science
in
Home Economics

Greensboro
June, 1962

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ACKNOWLEDGEMENT

The author would like to express her gratitude to Dr. Pauline E. Keeney, director of the thesis for her suggestions and guidance throughout the study; to Mrs. Frances Buchanan, Dr. Anna Reardon and Mrs. Helen Staley, members of the graduate committee for their suggestions; to Dr. Whitfield Cobb for his aid in establishing the statistical procedure; to Dr. Thomas Donnelly for his guidance in translating the statistical program; to Miss Mary Neely and Miss Denise Vick for their assistance in construction of garments and testing of fabrics; to Miss Betty Brooks, Miss Lynn Ligon, Miss Cara Ellen Nevell, Miss Fern Tuten and Mrs. Ida Kelly for evaluating the garments and to those twenty students who wore the garments during the testing periods.

Appreciation is also expressed to the Armour Industrial Chemical Company whose funds subsidized this study.

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CHAPTER I

INTRODUCTION

I. STATEMENT OF THE PROBLEM

Since the introduction of wash and wear fabrics many questions have been asked by consumers about their performance. Varied opinions have been expressed as to the success of resin-treated cotton fabrics particularly of those sold as wash and wear goods.

This study was planned to test the serviceability of five brands of wash and wear cotton fabrics available to consumers in the vicinity of Greensboro, North Carolina. Specific objectives were:

1. To evaluate the maintenance of wash and wear characteristics in five selected brands of cotton fabrics.
2. To compare the degree to which a selected softener (distearyl dimethyl ammonium chloride) affects the maintainance of wash and wear characteristics in those same brands of cotton fabrics.

In order to evaluate the in-use performance of wash and wear characteristics, garments constructed from the fabrics were worn and laundered. These garments were rated by the persons wearing them and by two different rating panels. Statistical interpretation of the data was based on the following null-hypotheses:

1. There is no significant difference in the surface appearance of the five brands of cotton fabric tested.
2. There is no significant difference in the surface appearance of those fabrics treated with a fabric softener and those fabrics which undergo normal laundry treatment.

3. There is no significant difference between the surface appearance of dark and pastel colors in those cotton fabrics tested.

II. IMPORTANCE OF THE PROBLEM

In recent years manufacturers have attempted to produce cotton fabrics with properties able to compete with fabrics made of the new synthetic fibers. The wash and wear field, initially begun with the synthetic fibers, has become the object of considerable research in the cotton industry. With the aid of resin treatments, cotton has entered the field and taken the leadership in the consumer demand of wash and wear garments.

Due to the position which cotton held previous to the advent of the synthetic fibers, many consumers prefer it for wearing apparel. For this reason cotton manufacturers have attempted to maintain the original "hand" while introducing the wash and wear properties. This combination of objectives has produced problems since those treatments which impart wash and wear properties to cotton often destroy the "hand" and other desirable properties. The success of resultant fabrics depends upon the individual manufacturer. The consumer's opportunity for the selection of wash and wear fabrics is at the discretion of both the textile and the garment industry. The only source of information the consumer has, either in the purchase of yard goods or ready-to-wear garments, is that which is released through advertisement. Even then, lack of standardization within the garment industry produces wide variations because interpretation of claims is largely a matter of personal attitide.

The consumer, having purchased a wash and wear garment, often has to take extreme caution in its laundering. As is true of many other treated fabrics, repeated washing may cause a wearing away of the properties imparted by the resin. In recent years fabric softeners have been made available for use in the home. It is reported that they add desirable properties to fabrics or help to maintain those properties imparted to the fabric during the manufacturing process. Included in the claims of fabric softeners are: (1) improving the appearance by fluffing the fabric and reducing wrinkling; (2) improving wearability by reducing soiling, eliminating static electricity and improving germicidal properties and (3) allowing for easier ironing by lubricating the fabric. It could be assumed from such claims that a softener would improve the wash and wear properties of a cotton fabric, and that the housewife would spend less total laundry time since ironing would not take so long.

III. ORGANIZATION OF THE STUDY

The remainder of this study is presented in four sections. Chapter II discusses published material pertaining to the production and use of wash and wear fabrics; the development and use of fabric softeners; and studies which relate to the evaluation of the performance of wash and wear fabrics. Chapter III outlines methods of procedure for (1) selecting and analyzing the fabrics; (2) construction and laundering of garments; and (3) evaluation of the serviceability in use. Chapter IV presents the results of the data obtained during this study. The summary, conclusions and recommendations for further study are included in Chapter V.

CHAPTER II

REVIEW OF LITERATURE

I. WASH AND WEAR

Definition of Wash and Wear

Since its advent as a term in the textile industry, wash and wear has been broadly interpreted by both manufacturer and consumer. Many fabrics are advertised as possessing wash and wear characteristics because the surface appearance of a fabric is determined to a large extent by subjective evaluation. Definition of the term, wash and wear, depends upon the interest of the observer with few persons or agencies venturing to be explicit. In order to be specific the following definition has been adopted: "Wash and wear fabrics are those which can be washed by any normal home washing procedure and will dry sufficiently smooth of wrinkles to allow them to be worn or used without ironing or pressing."[1]

Influence of Wash and Wear

The influence of wash and wear cottons has been evident to all parts of the textile industry. Cotton agriculturists are strongly aware of the fact that in 1958 wash and wear fabrics constituted ten per cent of the total domestic consumption.[2] According to Burr, figures from the

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[1]E. W. Laurence and R. H. Phillips, "Wash and Wear Fabrics," American Dyestuff Reporter, Vol. 45: No. 17 (August 13, 1956), 548.

[2]Carroll L. Hoffpauir and Boleslaus M. Kopacz, "Impact of Wash and Wear on Cotton Agriculture," Textile Bulletin (September, 1959), 31.

National Cotton Council of America estimated that cotton held sixty-three per cent of the nation's wash and wear market in 1960.[3] The Daily News Record reports that for the spring of 1960 seventy per cent of men's dress shirts sold in department stores were of wash and wear fabric and eighty-five per cent of those were of resin-treated cotton fabrics.[4] Manufacturers see from these facts the potential market of the chemical finishes. Apparel manufacturers have seen and are utilizing its implications as a stimulus for increased sales in cotton garments.

Properties of Wash and Wear

A cotton fabric classified as wash and wear must possess some properties not inherent in the natural fiber. The most essential characteristic which distinguishes a wash and wear fabric is that it resists wrinkling. The essential property is for the most part obtained by an "improved resistance to wet deformation or wet creasing, and also the ability to recover from such wet deformations during the drying cycle."[5] C. R. Williams made a more thorough study of the specific properties which such a fabric must possess and arrived at the following requirements for the ideal wash and wear fabric:

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[3] Francis Burr, "Ironing Out Wash-and-Wear Wrinkles," Chemical Week (September 23, 1961), 47.

[4] "Wash and Wear is Going Where?" Daily News Record, July 29, 1960, pp. 22, 30.

[5] Lawrence and Phillips, op. cit., p. 549.

Property requirements for ideal "wash-and-wear" cotton fabrics

Code	Property	Level of performance
A	Dry wrinkle recovery	= that obtainable with DMEU
B	Wet wrinkle recovery	= or > obtainable with DMEU
C	"Wash-and-wear"	5, by AATCC 88-1958, 3A and 4A
D	Tensile strength	= or > untreated
E	Tear strength	= or > untreated
F	Abrasion resistance	= or > untreated
G	Odor, odor development	none
H	Discoloration, hot chlorine	none
I	Discoloration, wash	none
J	Discoloration, 400°F scorch	= untreated
K	A, B, & C after 50 home launderings (HL)	= original
L	A, B, & C after 20 comm launderings (CL)	= original
M	Dimensional stability to 50 HLs	less than 1% shrinkage
N	Dimensional stability to 20 CLs	less than 1% shrinkage
O	Chlorine retention	none
P	Chlorine damage 50 HLs	none
Q	Chlorine damage 20 CLs	none
R	D, E, & F after 50 HLs	= or > untreated [6]
S	D, E, & F after 20 CLs	= or > untreated

Factors Influencing Wash and Wear Characteristics

Although it is not possible to rely upon any one factor as being the sole cause of wash and wear properties, some general implications may be stated concerning the relative importance of several factors.

Type of Fiber. Since the essential resistance to wrinkling is largely dependent upon the resistance to wet deformation, the type of fiber is most important. Low water absorption and high resilience, properties natural to many of the synthetic fibers, allow for better

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[6]C. R. Williams, "A New Reactant Resin for 'Wash-and-Wear' Finishing of Cotton Fabrics," American Dyestuff Reporter, Vol. 49, No. 12 (June 13, 1960), 431.

results.[7] For cotton to be successful in the field its hydrophillic nature must be converted by some other means into a durable hydrophobic nature.

Fabric Construction. Fabric construction is important in that a fabric which permits flexibility "by allowing the yarns freedom of movement relative to one another"[8] should promote high crease recovery. Such construction would be influenced by thread spacing, type of weave as well as coarseness of the yarns. Reid, in reporting upon the studies of W. H. Dribben and A. L. Lippart, confirms this statement. Dribben's study elaborates further to include low twist, coarse yarns, high crimp and low thread count as being factors which bring about this lack of strain within the fabric.[9] Studies of E. W. Lawrence and R. H. Phillips indicate loosely woven fabrics of coarse yarns to give better results other factors being equal.[10]

Color. The psychological effects of color on the fabric make it just as important as some of the physical properties. Detection of creases in a broken print pattern is much more difficult in that the design tends to camouflage the small wrinkles.[11] Plain-dyed fabrics generally show lower results with the outcome of highly reflective surfaces being especially poor.[12]

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[7]Lawrence and Phillips, loc. cit.

[8]Ibid.

[9]J. David Reid et. al. "Wash and Wear: Progress and Problems," Textile Industries (November, 1958), 5.

[10]Lawrence and Phillips, loc. cit.

[11]Reid, loc. cit.

[12]Lawrence and Phillips, loc. cit.

Creaseproofing Agents. The most important factor in determining the success of a cotton fabric as a wash and wear garment is the addition of a resin treatment. Such a resin is part of a wash and wear formula which may also contain a catalyst, a softening agent, water-soluble polymers and perhaps an optical bleach.[13] These thormosetting resins impart to cotton the essential characteristic of wash and wear fabrics--namely resistance to wet deformation and the ability to recover from such wet deformations during the drying cycle. These characteristics are obtained by one and/or both of two methods. Some resins coat or impregnate the fibers giving them a hydrophobic nature while others penetrate the fibers; thus causing a cross-linkage (sticking together) with the cellulose to increase the resilience and allow for good recovery from deformation. Nuessle states that in resins:

> . . . the molecule is small enough to penetrate into cotton or rayon fibers. There, under the influence of catalyst and heat, it will undergo a chemical reaction either with the cellulose, or with itself (forming a polymer), or both . . . . If the reaction is carried out in the dry state . . . both wet and dry crease recovery will be improved . . . . the reaction with cellulose can be carried out in the wet state . . . . In such a case, only the wet crease recovery will be improved.[14]

Secondary results include a hydrophobic nature, reduced shrinkage and decreased drying time--all desirable properties for the end result. However, such effects as decreased strength, decreased resistance to chlorine retention, and certain psychological differences in the "hand" of such fabrics tend to inhibit their complete success.

Wash and wear resins vary considerably in their chemical composi-

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[13]A. C. Nuessle, "Creaseproofing Agents for Wash-and-Wear Finishing," Textile Industries (October, 1959), 116.

[14]Ibid.

tion and, although results tend to follow the same trend, effectiveness and durability vary with each reactant. Because the consumer is concerned foremost with the total end results in a fabric, comparison of the more commonly used resins will be based on results of the physical properties important for use in a garment.

The most commonly used reactants for wash and wear are composed of nitrogen bases chemically combined with formaldehyde. These N-Methylol compounds have a major advantage of reacting easily with cotton and of being easily controlled.[15]

A. Urea-Formaldehyde.

The urea-formaldehyde resins were the first resins used for creaseproofing agents. They remain the most inexpensive and, therefore, the most widely used. According to the amount of formaldehyde and methanol resins within the group vary from each other.

In discussing their disadvantages A. C. Nuessle states:

> Some products are pre-polymerized. If carried too far this will produce a stiff hand on fabric and interfere with dry crease recovery . . . urea resins lack chlorine resistance, due in part to the fact that it is impossible to block all the $>$NH groups which pick up chlorine from the bleach baths . . . . durability of the creaseproofing effects will vary from fair to good . . .[16]

Other results show that undesirable secondary effects such as loss in tensile and tear strength and chlorine absorption have prevented urea-formaldehyde resins from becoming used extensively for crease resistance or shrinkage control.[17] Despite their faults the resins are used in

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[15]Ibid.

[16]Ibid., p. 117.

[17]Henry C. Speel and E.W.K. Schwarz, Textile Chemicals and Auxiliaries (New York: Reinhold Publishing Company, 1957), p. 414.

cases where hypochlorite bleaching is uncommon such as on colored goods. Urea-formaldehyde is also in widespread use in Europe where bleaching is uncommon.[18] They also serve as a base for many of the triazone resins to give a suitable finish and to reduce the cost.

B. Melamine-Formaldehyde

Melamine-formaldehyde resins comprise a large group of thermosetting resins. Products of this type are much more stable than the "UF" compounds and have found acceptance despite their higher cost. Advantages of this group lie in their "greater wrinkle resistance and better strength retention to the finished fabric."[19] Any strength loss "can be minimized or eliminated by the use of certain thermoplastic resins without the loss of crease resistance."[20] Nuessle reports that although there is some chlorine retention, degradation of the fiber is not so great due to the fact that the melamines tend to be basic in nature acting as buffers for any acid formation. The most detrimental factor of such resins is the tendency to yellow on chlorination. Although certain additives can modify this reaction, chlorination at temperatures above 140°F will usually give the cloth a yellow tinge.[21]

C. Cyclic Ureas

Although the group of cyclic ureas contains a large group of creaseproofing agents, only one has reached extended commercial impor-

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[18]Reid, <u>op</u>. <u>cit</u>., p. 7.

[19]<u>Ibid</u>.

[20]Speel and Schwarz, <u>op</u>. <u>cit</u>., p. 418.

[21]Nuessle, <u>loc</u>. <u>cit</u>.

tance. Dimethylol cyclic ethylene urea commonly called DMEU has become one of the most widely used of the wash and wear finishes comprising twenty-five per cent of the textile resin market.[22] Basically this reactant is simply "a modified urea-formaldehyde resin with the added group blocking the addition of chlorine."[23] Advantages of such a finish include a soft hand, durable crease resistance and superior chlorine resistance with no yellowing. When commercial sour baths are used hydrolysis of the finish occurs causing increased chlorine retention and increased losses of other properties imparted to the fabric by the finish.[24] C. R. Williams cites the formaldehyde odor as being another disadvantage if the fabric is not processed correctly.[25]

One other type of cyclic urea resin, triazones, has been used frequently in recent years. Most of these resins when used commercially are mixtures with urea derivative resins. Properties vary according to the composition of the particular triazone used, but their general success is based upon their ability to withstand chlorine damage after repeated washings. Like DMEU, commercial launderings cause rapid loss of desirable properties.[26] C. R. Williams states that triazones pass DMEU in chlorine resistance, but are "rated less efficient for wrinkle

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[22]Reid, _loc. cit._

[23]_Ibid._

[24]Nuessle, _op. cit._, p. 118.

[25]Williams, _op. cit._, p. 433.

[26]T. J. Cronin, Jr., "Progress in 'Wash-Wear' Finishing of Cellulosic Fabrics," _American Dyestuff Reporter_, Vol. 49, No. 11 (May 30, 1960), pp. 27-28.

recovery and wash and wear."[27] "The major disadvantages are tendency to yellow on ironing, either with or without chlorine present and the tendency to evolve fish odors."[28]

D. Other Resins

Other N-Methylol resins are available, even some non-formaldehyde finishes, but high cost has prevented their becoming strong competitors in the resin industry.

Due to the emphasis upon chlorine damage new creaseproofing agents with no nitrogen are being studied for possible use. Included in the non-nitrogenous group of resins are the acetals, the silicones and the epoxides as well as the alkaline wet creaseproofing agents. Most of these resins are more durable, but rate lower on crease recovery. T. J. Cronin emphasizes the fact that blends of various reactants are found to be satisfactory for commercial use. Epoxide resins with either DMEU or triazone resin will show acceptable performance while being low in cost.[29] A summarization of properties of resins presently on the market is as follows:

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[27]Williams, op. cit., p. 434.

[28]Nuessle, op. cit., p. 119.

[29]Cronin, op. cit., p. 29.

Properties of individual creaseproofing agents

Type	Advantages	Disadvantages
DMEU	High crease recovery, good "wash-wear"	Chlorine damage after multiple alkaline washes, not durable to commercial laundering
Triazone	High crease recovery, good "wash-wear," low chlorine damage	Slight discoloration on scorching, not durable to commercial laundering
Triazine	High crease recovery good "wash-wear", low chlorine damage, good durability	Slight tendency to yellow after repeated commercial white washes with scour
Acetal	Good "wash-wear", no chlorine damage, excellent durability	Slightly low crease recovery
Epoxide	Excellent durability, no chlorine damage	High cost and high add-on required for "wash-wear"
Alkaline wet creaseproofing	Excellent wet crease recovery and drip-dry, no chlorine damage	No dry crease recovery, poor tumble-dry appearance[30]

Problems of Wash and Wear

Though the extensive use indicates an apparent success of wash and wear garments, there are many problems yet to be solved. The Southern Regional Research Laboratory lists seven such basic problems:

1. To develop fabric construction suited for wash and wear, "including selection of the best suited cotton fiber, optimum yarn size and twist, and fabric geometry."[31]

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[30] Ibid.

[31] Reid, op. cit., p. 5.

2. To maintain good practices for fabric preparation prior to the resin application such as scouring, desizing and bleaching.

3. To select the best combination of resin-finishing agents, catalyst and other auxiliaries considering the use of the fabric.

4. To enforce the finishing techniques by stressing adequate cure and thorough after wash.

5. To design garments for wash and wear use with meticulous attention to details in cutting, fitting and sewing.

6. To establish standards which are clearly understood concerning the qualities of wash and wear.

7. To provide for permanent labels which give information concerning the laundering and caring for the garment.[32]

Future of Wash and Wear

Even though there are many problems present the future of wash and wear appears very bright. Textile leaders consider such fabrics as the stimulus for cotton in apparel and household goods. They are further impressed by the fact that the wash and wear resin can stabilize a fabric without preshrinkage and thus save yardage to the mill.[33] Some garment manufacturers emphasize the fact that wash and wear will have its greatest future in the lower and medium price garments;[34] while others expect it to dominate the market having the same popularity that sanforized garments have at the present.[35]

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[32]Ibid.

[33]Williams, op. cit., p. 433.

[34]Robert J. Whitt, "Wash Wear - A Plus Factor, but No Substitute for Style and Quality," Apparel Manufacturer, Vol. 36 (November 1959), p. 21.

[35]Hoffpauir and Kopacz, op. cit., p. 33.

II. FABRIC SOFTENERS

Influence of Fabric Softeners

Fabric softeners were created initially to improve the "hand" of various textile fibers. However, due to the widespread use of synthetic resins this has become one of their least important properties. Resin-treated fabrics, although permitting desirable wash and wear properties, have created adverse physical effects such as a reduced tensile and tear strength and a lessened resistance to abrasion. Introducing a softening agent in the same bath or in later treatments reduces the lowering of these important physical properties.[36] Consequently "practically all wash and wear goods are treated with additive softeners."[37]

Softening agents have been used in commercial laundries for several years, but only recently have they come into use for home laundering. Their claimed advantages are

> "to soften and fluff all washables; to improve their 'hand' or feel; to eliminate static electricity which makes fabrics 'cling;' to reduce wrinkling; to lubricate the fabric for simpler ironing, to reduce soiling and even to improve wear."[38]

The following is a typical formula:

> 75% cationic surface-active agent (usually a quaternary ammonium chloride or sulfate), 18% isopropanol and 7% water. This paste is further diluted with wetting agents (0.5-1%), odorants, tints, bluing and the like. Active ingredient percentage in the finished softener usually ranges from 3 to 8%.[39]

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[36] A. J. Hall, "New Role for Softening Agents in Textile Finishing - Part I," Textile Recorder, Vol. 77 (December, 1959), p. 66.

[37] Ibid., p. 41.

[38] "Fabric Softeners," Consumer Reports, Vol. 25 (January, 1960), p. 22.

[39] "Sales Spurt Puts New Zip into Fabric Softeners," Chemical Week, (December 30, 1961), p. 37.

Although the demand for softeners is increasing, lack of knowledge of their properties on the part of the general public has been a large drawback in the volume of sales. Present sales are estimated at twenty-five to thirty million dollars a year.[40] According to a survey in 1959 only twenty-two per cent of consumers questioned used a fabric softener while fifty per cent had never heard of the product.[41] A study in 1960 reports that 24.8 per cent of the persons interviewed used a fabric softener during the laundering process; 14.0 per cent of that population had been using the softeners for less than a year.[42]

Classification of Fabric Softeners

Fabric softeners are generally classified as surface-active agents or, to use the well-known contraction, as "surfactants." The term surfactant may be used, "to designate any substance whose presence in small amounts markedly alters the surface behavior of a given system."[43] Almost all of these materials consist of two parts, one part that is oil soluble and insoluble in water and the other part which is water soluble and allows the surfactant to be useful for the intended purpose.[44] Surfactants in the textile industry are used in such processes as the

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[40] *Ibid.*, p. 36.

[41] Armour Industrial Chemical Company, "A Market Research Report Covering a Nation-Wide Survey on . . . Fabric Softeners," (July, 1959).

[42] Homemakers Guild of America, *Summary of a Consumer Study of Household Products* (Conducted for the Household and Chemical Division of Owens-Illinois Glass Company), p. 6.

[43] Anthony M. Schwartz and James W. Perry, *Surface Active Agents* (New York: Interscience Publishers, Inc., 1949), I, p. 8.

[44] Speel and Schwarz, *op. cit.*, p. 303.

wetting-out of goods, scouring, dyeing, finishing and as emulsifying agents.[45] Fabric softeners are classified as agents necessary in the finishing process whether they are applied to a fabric in the mill or to a garment by consumers.

Although fabric softeners vary considerably in chemical composition, all cover the fiber with a very thin waxy coat which acts as a lubricant between the fibers.[46] These lubricating agents may be further divided into two classes: "the nonsubstantive types [not directly attached to the surface] which for the most part are anionic or nonionic in nature, and the substantive softeners which are based on cation-active compounds."[47]

Substantive or cation-active softeners are much more effective than those of the non-substantive group. Non-substantive softeners cause a loose covering of the fiber resulting in an oily film and suedy feel.[48] They can be removed easily in the laundering process. The substantive agents exhibit a firm bonding with a higher degree of softening power. These materials disperse in water and ionize in such a way that the cation is attracted to the negatively charged fibers. This affinity results in a more durable finish with little or no softener being dis-

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[45] Ibid., p. 404.

[46] "Fabric Softeners," loc. cit.

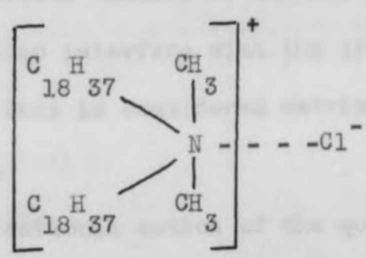
[47] William S. Sollenberger, "Cationic Softeners - Their Secondary Effects on Textile Fabrics," American Dyestuff Reporter, Vol. 46, No. 2 (January 28, 1957), p. 41.

[48] Paul DuBrow and Werner M. Linfield, "Cationic Fabric Softeners," Soap and Chemical Specialities, Vol. 133 (April, 1957), p. 91.

carded afterwards. For these reasons most information relating to fabric softeners has been limited to those of the substantive type. Although some of the statements made in the following sections may apply to both classes of lubricating agents, the substantive softeners are the only type discussed.

Nature and Structure. The softening of the textile fiber is dependent upon such factors as flex and compressibility, but largely upon the lubricating powers which allow for yarn and fiber slippage.[49] Lubrication occurs when the fatty material which acts as a cation exhibits hydrophobic properties. The thin coating deposited on the fibers results in good internal lubrication of the fabric by permitting the fibers to slip over each other.[50]

Most typical of these cationic softeners are the quaternary ammonium salts of which distearyl dimethyl ammonium chloride is an example.



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Although the structure of the quaternaries is variable in complexity, all "share a fundamental electrochemical property; they dissociate to

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[49] Ibid., p. 89.

[50] Home Economics Laboratory of Texize Chemicals, Inc., Research and Development.

[51] Sollenberger, op. cit., p. 42.

form a relatively large cation and a relatively small anion."[52] Compounds are sold in an alcohol and water solution. "The alcohol serves to dissolve the quaternary ammonium salt, the water to insure dispersion in the rinse.[53]

Characteristics. Characteristics of the quaternaries vary in degree according to composition of a particular softener, but are similar to some extent in all such compounds.

Although repeated launderings will cause a loosening and consequent wearing away of the softener, reapplication will result in renewing of the coating and sometimes a gradual building up of the softener. This built-up softener can turn to a disadvantage in extreme cases in that a suedy or tacky surface will cause a picking up of soil from the laundering solution.[54] This so called wet soiling, a problem in the textile industry, would not ordinarily occur in household laundering unless the consumer used excessive amounts of the softener. Excessive softener application will also interfere with the ability of the fabric to absorb water.[55] Whether this is considered detrimental depends upon the end use of the fabric.

Due to the cationic action of the quaternaries they are not com-

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[52]D. L. Anderson, "A Comparison of Quaternaries and Amphoterics," Soap and Chemical Specialities, (April, 1961), p. 60.

[53]Jane Ashley, "Home Laundry Fabric Softeners," Home Service Department, Corn Products Refining Company (October, 1957).

[54]Terrance W. Fenner, M. Reinhardt and J. David Reed, "New Methods for Improving the Wear Resistance of Wash-Wear Cotton Collar and Cuff Materials," Textile Bulletin Vol. 87, No. 11 (November, 1961), p. 41.

[55]"Fabric Softeners," op. cit., p. 23.

patible with anionic substances such as soaps or synthetic detergents. If the softener comes into contact with such a substance, a double decomposition action will occur precipitating an insoluble salt.[56] This has proved to be a problem in household softening because it necessitates the consumer introducing the softener in the final rinse cycle and preferably in an additional rinse.

The fact that fabric softeners exhibit improved fiber tear strength has been attributed to the "internal lubrication which reduces the effect of abrasion,"[57] by allowing a more even distribution of stress. A study by William S. Sollenberger revealed that there was a tear strength gain of about twenty-five per cent on cotton fabrics.[58] The following table illustrates results of a study by A. J. Hall showing the effects of a polyethylene emulsion upon resin-treated cotton fabrics.

Resin	Polyethylene Emulsion Per Cent	Crease Recovery Angle-Warp	Tear-Strength (lb.) Warp	Tear-Strength (lb.) Weft
Dimethylol ethylene urea	0	128	450	210
	3	140	670	350
Methylated melamine formaldehyde	0	132	490	210
	3	146	640	300
Methylated urea-formaldehyde	0	131	480	210
	3	138	670	300
Water-soluble epoxy resin	0	127	480	210
	3	128	530	290
None	0	69	750	430

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[56] Armour Industrial Chemical Company, Arquads--Quaternary Ammonium Salts, (1956), p. 4.

[57] DuBrow, op. cit., p. 93.

[58] Sollenberger, op. cit., p. 49.

[59] A. J. Hall, "New Role for Softening Agents in Textile Finishing - Part II," Textile Recorder, Vol. 77, No. 922 (January, 1960), p. 64

Although static electricity is not normally a problem with cotton fabrics, it is a major drawback to the synthetic hydrophobic fibers. Friction builds up on such surfaces because there is no conductor such as moisture to ground the charge.[60] A cationic softener applied to the surface of such fibers absorbs moisture from the air to form a thin film which dissipates static charges. Quaternary ammonium compounds have proved under test condition to be very effective in this antistatic property.[61]

Germicidal properties of certain quaternary ammonium compounds are widely advertized. Softeners can serve as sanitizing agents preventing mold or mildew and functioning as deodorizers. However, this property dimenishes unless reapplication occurs in subsequent laundering.[62]

> . . . Solutions of one part ammonium salt in 20,000 parts water will kill common disease causing bacteria within 10 minutes in vitro. Tests by a modified Agar plate method showed that fabric treated with a quaternary ammonium salt will prevent the transfer of Staphylococcus aureus, the common cause of boils. Some of these salts are active against Bacillus ammoniagenes, an organism that decomposes the urea in urine to ammonia which is believed to be the cause of diaper rash.[63]

The lubricating characteristic possessed by softeners is the one feature most desired by consumers. Due to the easing of tension between the fibers the following results could occur.

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[60] Harold L. Ward, "Textile Softeners for Home Launderies," Journal of Home Economics, Vol. 49, No. 2 (February, 1957), p. 122.

[61] Sollenberger, op. cit., p. 57.

[62] DuBrow, op. cit., p. 95.

[63] Ward, op. cit., p. 123.

1. A reduction of wrinkling during wear and laundry through uniform distribution of the strains imposed upon the fiber.[64]

2. A softer "hand" to the fabric by the presence of the fatty materials in the fiber coating.

3. A fluffing action based on the hydrocarbons at the free end of the cation molecule which cuts down on compression on the fabric.

4. Better fabric sewability and reduced needle cutting by allowing the needle to push the fiber aside rather than cutting the thread. "On one wool nylon shirt, at 4500 stitches/min. only one to two yards could be sewn; with the softener, a minimum of 52 yards."[65]

Studies of Softeners as Applied to Fabrics

Studies concerning the fabric softeners are relatively few. The theory of their action is more often found than studies of their tested results on a specific fabric or article.

Consumer Reports tested five brands of commercial softeners on bathroom linens and diapers by both tumble-dry and drip-dry methods. Conclusions were that all pieces were softened considerably; but that the differences were more obvious with drip-drying than with tumble-drying. A follow-up study on wash and wear suits indicated that all softeners were equally effective in improving the surface appearance. However, those same softeners had no apparent effect on the wrinkling of pillow cases or yard goods swatches.[66] Studies by A. J. Hall and

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[64]"Fabric Softeners," op. cit., p. 22.

[65]DuBrow, op. cit., p. 93.

[66]"Fabric Softeners," loc. cit.

George L. Drake indicate the advantage of adding softening agents to resin-treated fabrics.[67]

A study of softeners on medium to medium-high priced garments by Rose V. White revealed that surface appearance was improved. However, this did not eliminate the need for ironing cotton garments. It is interesting to note from her results that no one cotton garment was rated as being "wash and wear" in the strictest sense. Those synthetic garments tested were more receptive in that twenty-five per cent of the garments laundered with a softener and without ironing received a rating of "Unquestionable in Appearance"[68] William S. Sollenberger conducted a study to test the effects on fabrics of nine cationic softeners. In addition to those results cited previously he found that quaternary ammonium chlorides produced only insignificant changes in color while causing a slight increase in seam strength.[69] Recent test results from a textile laboratory using a fabric softener on untreated and resin-treated fabrics were summarized as follows:

> Although there is some improvement in the wash-wear appearance of these fabrics by the addition of a fabric softener during the wash cycle, it is felt that the improvement is not significant enough to make it worthwhile.

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[67]Hall, Part I, op. cit., p. 65; George L. Drake, Jr., John V. Beninate and John D. Gutherie, "Application of the APO-THPC Flame Retardant to Cotton Fabrics," American Dyestuff Reporter, Vol. 50, No. 4, (February 20, 1961), p. 31.

[68]Rose V. White, "Home Laundry Finishing Aids--Fabric Softeners and Starches," The "How To" of the Modern Home Laundry Basket, Twelfth National Home Laundry Conference, (1958), Sponsored by American Home Laundry Manufacturers Association, p. 22.

[69]Sollenberger, op. cit., p. 49.

Some yellowing or graying of the fabric was noted particularly on resinated samples when a softener was included in the rinse cycle.[70]

III. STUDIES HELPFUL IN DEVELOPING PROCEDURE

Studies Related to Construction of Wash and Wear Garments

It has been pointed out that fabric design and construction are very important in predicting the success of wash and wear properties in a fabric. Garment design and construction techniques are of even greater importance in the prediction of the success of such a garment. Construction of wash and wear suits has proved that since the fabric resists molding or shaping, the garment must be cut to shape. There can be no allowance for "play or leeway or stretch . . . ."[71] In sewing of the garment seam appearance is of foremost interest. Puckers which might be pressed out in the ordinary garment will be very obvious in wash and wear garments. Puckers which occur as the result of these "sewn-in" defects or from the shortening of the stitch line would necessitate pressing even if the fabric used possessed ideal wash and wear properties. Puckering from shortening of the stitches can be avoided by reducing the lower and upper tension to the lowest possible level for good sewing. Puckers resulting from displacement of the fabric along the seam line are also detrimental to the appearance of the garment.

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[70]Robert H. Phillips, "Project #647 Dri-Smooth Finish Evaluation of Fabric Softeners on the Wash and Wear Properties of Fabrics," (Cranston Print Works Company Research and Development Laboratories, July, 1960).

[71]L. Richard Haspel, "Making Well-Constructed Garments," "Wash and Wear" Fact or Fantasy, 11th National Home Laundry Conference (1957) Sponsored by American Home Laundry Manufacturers Association, p. 22.

Displacement forces the "yarns to assume a more irregular path in the fabric and shortens the overall length."[72] The following techniques will help eliminate this fabric displacement: (1) using the smallest thread available while retaining sufficient strength for wear; (2) designing garments with as many seams of the bias as possible; (3) reducing the number of stitches per inch; (4) using a fine needle in the sewing operation; and (5) reducing pressure on the fabric by lowering the feed dog and loosening the spring of the pressure feed.[73] Proper finishing of seams is duely important in the fraying or raveling can cause puckers which are noticeable on the outside of the garment.[74] Design of garments should be such that seams are minimized both in number and style. Felled seams, top stitching and other multiple seaming would result in more fabric distortion and, therefore, more pucker. Pockets, darts and "trims" may also serve to decrease the wash and wear rating. In summary, garment design should be of a simple style which permits only a minimum of extraneous factors relating to construction to detract from the surface appearance of the fabric.

Studies Related to Laundering of Wash and Wear Garments

Laundering techniques present another factor in determining the appearance of wash and wear garments. In a study performed at Purdue University it was found that the following conclusions could be made from the results on wash and wear cotton shirts:

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[72]"Wash and Wear Garments Require Proper Sewing Techniques," America's Textile Reporter, Vol. LXXIII No. 34 (August 20, 1959), p. 41.

[73]Ibid., p. 43.

[74]Ibid.

1. Both fabric squares and shirts laundered at 105°F. were rated higher than those laundered at 140°F.

2. Hand action produced fewer wrinkles than the action of a tumble-type home washing machine.

3. A two-pound load caused less wrinkling than a four-pound load at 105°F. and drip-drying.

4. Wrinkling increased in most cases when subjected to fifteen washings.

5. Evaluation of fabric squares can be used to predict the wrinkling of garments made from those fabrics.[75]

Studies of laundering procedures by the United States Department of Agriculture showed that the following variable left the fabric swatches with the least number of wrinkles:

> . . . 60°F washing temperature rather than 100°F, 100°F rather than 140°F; five-pound rather than seven-pound load, rack dried; tumble drying rather than rack drying if full washer cycle was used; and drip-drying rather than tumble drying if no water was extracted.
>
> There were trends for less wrinkling from four minutes of agitation rather than eight; agitation at regular speed rather than a slow; spin time shortened to 1/3 rather than full spin time; 60°F rinse rather than 100°F; three-pound load rather than five- or seven-pound, if rack or tumble dried; tumble-drying temperature of 150°F rather than 130° or 180°F (all ± 10°F); and tumble drying without heat for 10 minutes after drying was complete compared with not drying after drying.[76]

The type of washer--agitator or tumbler--made little difference in the wrinkling of such swatches.[77] A later study by this same group concluded

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[75]Melba Burton Shilling and Rose W. Padgett, "The Effect of Laundering Methods on the Wrinkling of Wash-and-Wear Cotton Shirts," American Dyestuff Reporter, Vol. 50, No. 3 (February 6, 1961) p. 62.

[76]R. Katherine Taube, Enid S. Ross and Nada D. Poole, "Use of Modern Home Laundry Equipment Part I 'Wrinkling Effects on Swatches of Present-Day Fabrics,' American Dyestuff Reporter, Vol. 50, No. 13 (June 26, 1961), p. 40.

[77]Ibid.

that: (1) the soap was more effective in removing soil than the synthetic detergent; (2) tumble-dried blouses were rated less wrinkled with less puckering of the seams than blouses which had not been rack dried (cotton blouses needed ironing even then); (3) gas drying left large amounts of oily residue in the fabric. Because the whiteners in the syndet were more effective the syndet tended to give better results.[78]

Studies Related to Evaluation of Wash and Wear Fabrics and Garments

Subjective evaluation methods vary somewhat in the techniques which they employ. A study by Shilling and Padgett judged shirts by observing the relative frequency with which dissatisfaction was expressed over areas of the shirt such as wrinkled collar, puckered seams, wrinkled cuffs, puckered pockets and overall wrinkling.[79] Other evaluation techniques used in a study of wash and wear men's suits asked for degrees of comparison--none, slight or obvious--for rippling and shrinkage of lapels and seam edges, puckering at the armscye, collar stretch, color change, change in the body, pilling and spot and stain retention.[80] Results of this study indicated that "70% of the wet cleaned and dry-cleaned garments were rated from very good to fair, whereas 70% of those which were laundered as fair to poor."[81]

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[78]Nada D. Poole, Enid S. Ross, and R. Katherine Taube, "Use of Modern Home Laundry Equipment II. Cleaning and Wrinkling Effects on Low-Temperature Wash Solutions on Naturally Soiled Blouses," American Dyestuff Reporter, Vol. 51, No. 1 (January 8, 1962), p. 23.

[79]Shilling and Padget, op. cit., p. 26.

[80]T. Faye Mitchell, June C. Wilbur and Eleanor Young, "A Study of the Performance of Selected Wash and Wear Suits," Textiles and Clothing Department, College of Home Economics, University of Maryland, Research Publication No. 20, pp. 42-44.

[81]Ibid., p. 45.

At the present time even the most objective of methods used for wash and wear evaluation has not been given complete approval. Techniques now used are based on comparison of some standard with the wrinkles of a fabric swatch. AATCC Method 88-1960 provides for the evaluation by visual comparison with three dimensional plastic replicas under various lighting conditions. Low-angle lighting observation has proven to be more discriminating in that the shadows of the surface irregularities serve as a good indication of the number and depth of the wrinkles. Numerical ratings are made by panel members who compare swatches with the replicas until the most similar one is found. Although this method is similar to that of consumer evaluation, it is open to a large degree of human error.

Techniques are now being tested which use instruments rather than human judgment for the numerical ratings. The Hunter Wrinklemeter judges degree of wrinkling by the distribution of a low-angle light over the surface of the fabric. Interpretation by the Cluett-Peabody Smoothness Evaluator involves placing the fabric on a revolving drum which rotates under an optical system which then converts and decides upon the rating.[82] "The Dupont LAP method depends upon the casting of a slit of high intensity light on the fabric using a light projector at a low angle with respect to the fabric."[83] The resulting contour lines can be analyzed manually or electronically to determine the degree of wrinkling.

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[82]Graham M. Richardson, "Wash and Wear - A Progress Report for 1960," American Dyestuff Reporter, Vol. 49, No. 20, (October 3, 1960), p. 30.

[83]Ibid., p. 31.

Evaluations of wash and wear have for the most part employed the use of Monsanto plastic replicas. This is done by the low-angle lighting conditions usually or by hanging a garment under specified overhead lighting. Although some studies indicate that such standards are not very reliable, they represent the most widely used technique in the United States.[84]

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[84] Z. M. Sudnick, "Comparison of Standards for Assessing Wrinkling of Fabrics," Textile Research Journal, Vol. 31, No. 1 (January, 1961), p. 79.

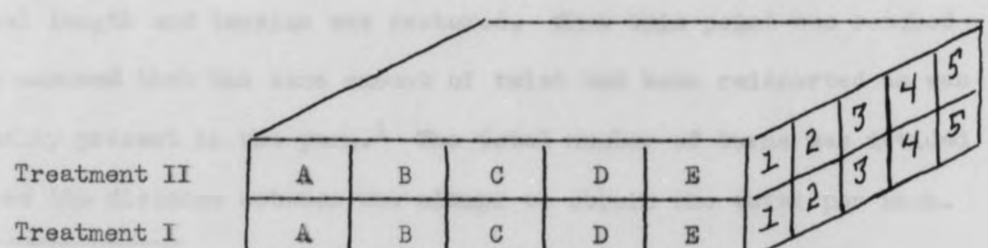
CHAPTER III

METHODS OF PROCEDURE

I. Purchasing of Sampling Pattern Fabrics

The statistical design of this study called for the construction of forty garments from five different brands of "wash and wear" cotton fabrics. In order to determine the effects of color upon surface appearance, four colors--two pastels and two dark colors--were chosen from each brand. Of these garments twenty under-went normal washing procedure while twenty received an additional treatment of distearyl dimethyl ammonium chloride fabric softener.

Prior to the purchase of the yard goods needed for the garments a preliminary study was conducted to determine brands and colors available in local department stores and fabric shops. On the basis of this information five brands of cotton wash and wear fabrics were selected. While the brands chosen were representative of the local range in prices, the selection of the particular brands was determined by the availability of similar colors. Green and pink were chosen to typify pastels while navy blue and brown were chosen to typify dark colors.



II. Determination of Physical Characteristics of Fabrics

Physical differences and/or similarities among the various brands were established by the following tests: staple length, twist count, weight per square yard, thread count, yarn number and colorfastness. The performance of the fabric, both before and after use, was indicated by tear strength, wrinkle recovery and dimensional change. These tests were applied to both control and experimental fabrics.

Staple Length

The mean length of fibers in each brand was determined by untwisting a yarn until it could be pulled apart easily without breaking individual fibers. Fibers were extracted from the tufted ends and measured to the nearest sixty-fourth of an inch. Eight warp and eight filling counts were made on each brand of the wash and wear fabrics.

Twist Count

Approximations of turns per inch for both warp and filling yarns were made following ASTM Designation: D 1422-59T. A twist counter manufactured by the United States Testing Company was used for measurement. The twist was taken out of a known length of yarn mounted under a given tension; then twist was inserted in the opposite direction until the original length and tension was restored. When this point was reached it was assumed that the same amount of twist had been reinserted as was originally present in the yarn.[1] The total number of turns was divided by twice the distance between the clamps to obtain the twist per inch.

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[1]ASTM Committee D-13 on Textile Materials, ASTM Standards of Textile Materials (Philadelphia: American Society for Testing Materials, October, 1961), p. 587-589.

$$\text{Twist per inch} = \frac{\text{Total number of turns}}{2\ (\text{Distance Between the Clamps})}$$

Twenty tests were made of both the warp and filling yarns in each of the brands.

Weight Per Square Yard

Ounces per square yard were determined by cutting three 2 x 2 inch samples from each color in each brand. These squares were oven-dried and weighed to the nearest thousandth of a gram. The mean of twelve samples was taken as the weight in grams per square yard and converted to ounces per square yard by the following formula:

$$\text{Ounces per square yard} = \frac{\text{weight of sample in grams} \times 45.72}{\text{area of sample in square inches}}\ ^{2}$$

Thread Count

The number of warp and filling threads per inch was determined by use of a mechanical pick counter.[3] Twelve readings of both warp and filling threads of each brand were taken.

Yarn Number

Yarn number was determined by use of the Roller-Smith Universal Yarn Numbering Balance. Yarns totaling thirty-six inches in length were placed on the balance and the appropriate yarn number read directly from the scale. Three readings of both warp and filling yarns were taken in each color of each brand.

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[2] Ibid., p. 824.

[3] Ibid., p. 823.

Colorfastness

The ability of a fabric to resist color destroying agents was tested by three methods:

1. Colorfastness to Rubbing. Transfer of color from the surface by rubbing was determined by use of a Standard Cloth Crockmeter. The test specimen was rubbed with standard crock cloth under controlled conditions. Color transferred to the crock cloth was compared to standards as designated by AATCC Test Method 8-1961.[4] Two samples - one wet and one dry - were tested for each color of each brand.

2. Colorfastness to Light. Colorfastness to light was evaluated by use of the Carbon-Arc Lamp Test as prescribed by AATCC Test Method 16A-1960.[5] A sample of each color in every brand was exposed to twenty, forty, and sixty hours of carbon arc light in a standard fadeometer.

3. Colorfastness to Laundering. Accelerated laundering tests were performed to determine colorfastness. Samples of each color in each fabric to which a 2 x 2 inch sample of multifiber fabric had been attached were washed under controlled conditions as prescribed by Procedure I of AATCC Tentative Test Method 61-1961T.[6] Evaluation was based on color transfer to the multifiber cloth and by comparison with the original fabric.

Tear Strength

The average force required to continue a tear once started was calculated by use of the Elmendorf Tear Tester as specified by ASTM Standard D 1424-59.[7] Three warp specimens and three filling specimens were used in each color of each brand of fabric.

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[4] William D. Appel (ed.), 1961 Technical Manual of the American Association of Textile Chemists and Colorists, Vol. XXXVII (New York: Howes Publishing Company, September, 1961), pp. 86-87.

[5] Ibid., pp. 90-91.

[6] Ibid., p. 105.

[7] ASTM Standards of Textile Materials, op. cit., pp. 597-601.

Wrinkle Recovery

Recovery of the fabrics from wrinkling was obtained by creasing and compressing specimens under controlled conditions after which the recovery angle was measured. AATCC Tentative Test Method 66-1959T was followed using the Monsanto Wrinkle Recovery Tester.[8] A total of twelve samples--three specimens from each color--were used in both warp and filling direction.

Dimensional Change

Dimensional change was determined by marking a 15 x 15 inch square on the portion of fabric added to the laundering procedures for physical tests. Linear measurements were made at three different places in both warp and filling direction along the square.[9] Two such squares were marked--one to be laundered with the control garments and one with the experimental garments. After five washing treatments, measurements were repeated and dimensional change was reported as the percentage of the original measurement.

III. Garment Construction

The garment constructed was of a simple style in keeping with recommended styling of "wash and wear" fabrics. The commercial pattern design selected was a shirt-type blouse with roll-up sleeves and back yoke (Figure 1). Efforts were made in the cutting and sewing processes

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[8]Appel, op. cit., pp. 156-157.

[9]John H. Skinkle, Textile Testing (New York: Chemical Publishing Company, 1940), p. 83.

to achieve a standardized appearance of the forty blouses by having the several operators follow the same general procedures.

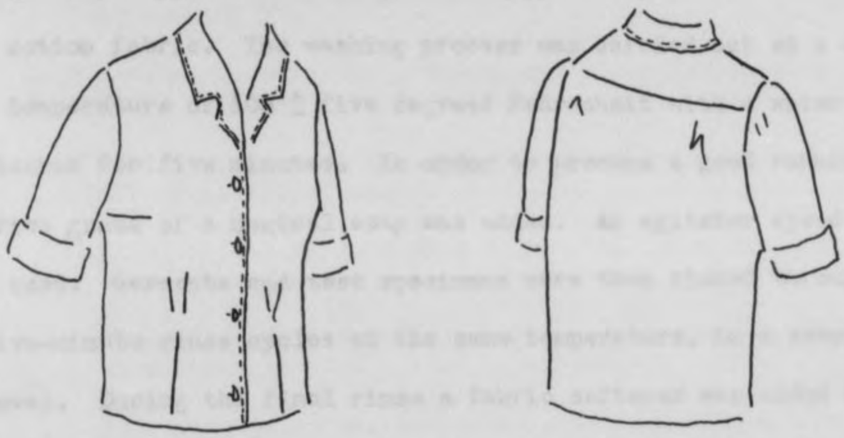

FIGURE 1

STYLE OF BLOUSE USED IN THE STUDY

IV. Wear Testing

Tentative Rotation of the Garments

Twenty students from classes of clothing or textiles at the Woman's College participated in the wear testing program. Each student wore both the control and the experimental blouse in a particular color and brand. These two blouses were alternated in wear testing until both had undergone five washings. Written and oral instructions were given to students specifying the handling of the garments. The blouses were divided into two groups, each group containing ten control garments and ten experimental garments.

Laundering Procedure

Garments and test specimens were separated according to the lightness or darkness of color and laundered in a cylindrical washer with a reverse wash wheel. Five pounds was designated as the normal wash load. Any supplementary weight was supplied by pieces of similarly colored cotton fabric. The washing process was carried out at a controlled temperature of 105 ± five degrees Fahrenheit with a water level of six inches for five minutes. In order to produce a good running suds twenty-five grams of a neutral soap was added. An agitator speed of 36 rpm was used. Garments and test specimens were then rinsed through three five-minute rinse cycles at the same temperature, in a seven inch water level. During the final rinse a fabric softener was added to those garments designated as experimental blouses. Following the final rinse, garments were removed and hung on hangers to drip-dry at room temperature. Garments were smoothed by hand to assure drying with the best possible results in appearance.

V. Evaluation Procedures

To fulfill the objectives of the study garments were appraised by both a subjective and non-subjective method. All garments were hung in a room conditioned at 70° ± 2°F. and 65% ± 2% r.h. for at least sixteen hours prior to evaluation.

Subjective Rating

Subjective evaluations were made prior to wear testing and at each washing interval. Each garment was evaluated by the student wearing it and by a rating panel of three persons. In this appraisal evaluators were asked to rate numerically specific areas of the blouse as well as the garment as a whole (Appendix A). Numerical ratings were based on the following verbal description.

5 = Excellent, free from wrinkles, one would have no objection to wearing it.

4 = Very good, wrinkles present, but the appearance is still above average.

3 = Good, wrinkles present but of such dimension that the effect is satisfactory.

2 = Fair, wrinkling to such a degree that it gives the blouse a bad appearance.

1 = Poor, excessive wrinkling; one would object to wearing this garment.

Appraisal by the rating panel was conducted under conditions similar to natural observations of clothing. Examples of garments illustrating the extremes of the rating scale were also available (Figure 2).

Non-Subjective Rating

Surface appearance was rated by a non-subjective method using the Monsanto Three Dimensional Standards with a Cranston Light Source. Five plastic replicas of wrinkled fabrics were used as the standard for the evaluation of the surface appearance of each fabric. A numerical rating was assigned to the back panel of each garment by each member of a panel of three persons. The personnel of this panel differed from those giving the subjective rating. Replicas were rated from five, the highest rating, to one, the lowest rating. Observations were made under a low-angle observation as recommended by AATCC Tentative Test Method 88-1960T (Figure 3).[10] Ratings by the Monsanto Standards were made prior to actual wear testing and at each washing interval.

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[10] Appel, *op. cit.*, p. 117.

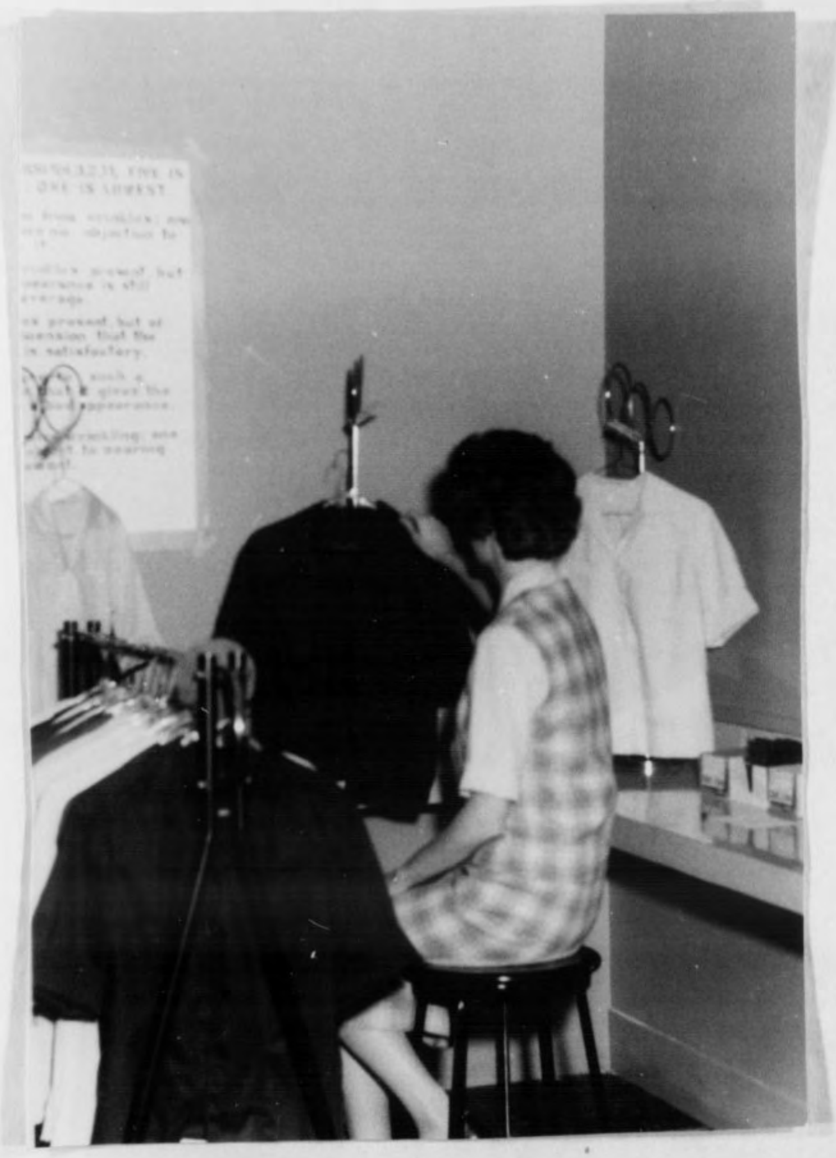

FIGURE 2

APPARATUS FOR SUBJECTIVE EVALUATION

FIGURE 3

APPARATUS FOR NON-SUBJECTIVE EVALUATION

FIGURE 3

APPARATUS FOR NON-SUBJECTIVE EVALUATION

Analysis of Data

Data from both the subjective and the non-subjective evaluations were analyzed using the analysis of variance. In order to evaluate the changes in appearance in the garments the analysis of variance was used to test the differences between the ratings of the unlaundered fabrics and the ratings given to those same garments following each laundering interval. The main effects and the first and second order interactions of the four variables--brands, colors, treatments and judges--were tested at each washing interval. F values were computed to determine the significance of each variable in order to test the null-hypotheses. The pattern for analysis is presented in Table I.

Programming of Data

The data for this study were processed by the Remington Rand Univac 1105 Data Automation System in the Research Computation Center of the Consolidated University of North Carolina. The statistical program was prepared for the computer in the IT (Internal Translator) language and recorded on punched cards. Data needed for each test were recorded on paper tape. The program as translated into machine language is presented in Appendix B. Code numbers from the program which were used in the analysis of variance are listed in Table II.

TABLE I

PATTERN FOR ANALYSIS OF VARIANCE

Source of Variation	Degrees of Freedom		Sum of Squares (Unlaundered minus laundered fabrics)	Mean Square	F values
Colors	(c-1)	= 1			
Brands	(b-1)	= 4			
Treatments	(t-1)	= 1			
Judges	(j-1)	= 2			
C x B	(c-1) (b-1)	= 4			
T x B	(t-1) (b-1)	= 4			
C x T	(c-1) (t-1)	= 1			
T x J	(t-1) (j-1)	= 2			
C x J	(c-1) (j-1)	= 1			
B x J	(b-1) (j-1)	= 8			
C x B x T	(c-1) (b-1) (t-1)	= 4			
C x B x J	(c-1) (b-1) (j-1)	= 8			
B x T x J	(b-1) (t-1) (j-1)	= 8			
C x T x J	(c-1) (t-1) (j-1)	= 2			
Residual	(R-1)	= 68			
Total	T-1	= 119			

c = colors
b = brands
t = treatments
j = judges

TABLE II

UNIVAC CODE NUMBERS USED FOR ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean square	F values
Color	1	Z 92	Z 126	Z 140
Brand	4	Z 93	Z 127	Z 141
Treatment	1	Z 94	Z 128	Z 142
Judge	2	Z 95	Z 129	Z 143
CxB	4	Z 96	Z 130	Z 144
TxB	4	Z 97	Z 131	Z 145
CxT	1	Z 98	Z 132	Z 146
CxJ	2	Z 99	Z 133	Z 147
TxJ	2	Z 100	Z 134	Z 148
BxJ	8	Z 101	Z 135	Z 149
CxBxT	4	Z 102	Z 136	
CxBxJ	8	Z 103	Z 137	
BxTxJ	8	Z 104	Z 138	
CxTxJ	2	Z 105	Z 139	
Residual	68	Z 107	Z 125	
Total	119			

CHAPTER IV

PRESENTATION OF DATA

The major objectives of this study were to determine (1) the differences in appearance and performance of five brands of wash and wear fabrics, and (2) whether the surface appearance and specific physical properties of the fabrics were affected by the application of a fabric softener.

I. SELECTION OF FABRICS

Five brands of cotton fabrics were purchased from department stores and fabric shops in the vicinity of Greensboro, North Carolina. Prerequisites for selection included a cotton of broadcloth or percale construction with a wash and wear label or other indications that the fabric possessed wash and wear properties. Eight brands of wash and wear fabrics were available in the eleven stores surveyed. Availability of the four colors needed was, in most cases, the determining factor for purchase of the specific brands selected for the study. Prices of the fabrics purchased ranged from $.49 to $1.19 per yard. Table III shows the availability of brands of wash and wear fabrics in the Greensboro area.

II. ANALYSIS OF CONSTRUCTION AND SERVICEABILITY OF UNLAUNDERED FABRICS

Prior to washing the fabrics were tested to determine the differences existing in the brands of fabric selected for use. Characteristics

TABLE III

AVAILABILITY OF BRANDS OF COTTON WASH AND WEAR FABRICS

Source	Brands							
	A	B	C	D	E	F	G	H
1	X	X			X			
2	X						X	
3		X						
4		X			X	X		
5						X		
6			X					
7				X				
8		X					X	
9		X	X	X	X			X
10					X			
11								X

of fabric construction and indications of serviceability served to determine whether these differences were significant.

Fabric Construction

All of the cottons used in this study were similar to each other in fabric construction. The greatest differences among the fabrics were in the thread count and yarn number. Variations in staple length, twist per inch and weight per square yard were not considered differences of importance. Detailed results of the laboratory results performed at the zero interval are presented in Table IV.

Staple Length. There was little variation in the staple length of the five brands of cotton fabrics tested. All of the yarns were approximately one inch in length and were considered to be cottons of average staple length. The mean warp staple length ranged from 1.11 inches to 0.91 inches. The mean filling length ranged from 1.16 inches

TABLE IV

FABRIC CONSTRUCTION

Properties	Brands of fabric				
	A	B	C	D	E
Staple length (Inches)					
Warp	1.03	1.11	1.02	0.91	1.08
Filling	0.99	1.16	1.06	0.81	1.04
Twist					
Warp	22 Z	22 Z	26 Z	21 Z	25 Z
Filling	22 S	23 Z	22 S	26 Z	25 Z
Ounces per square yard	3.32	3.34	3.17	3.23	3.36
Thread count					
Warp	88	105	84	88	104
Filling	80	55	75	76	59
Yarn number					
Warp	38's	33's	44's	32's	32's
Filling	36's	34's	30's	39's	40's

to 0.81 inches. Brand D was the only fabric with fibers of less than one inch staple length in both the warp and filling yarns. Brand B had fibers of the longest staple length in both directions.

Twist Count. Warp yarns ranged from 26 to 21 in turns per inch. Filling yarns ranged from 26 to 22 turns per inch. With the exception of the filling yarns in Brands A and C, all turns were in the Z direction. Single yarns were used in both the warp and the filling direction of all fabrics.

Weight Per Square Yard. The differences in weight per square yard were slight, ranging from 3.36 ounces per yard to 3.17 ounces per yard. Brands A, B, and E were of approximately the same weight while Brands C and D were of slightly lighter weight.

Thread Count. The differences in thread count among the brands of wash and wear fabrics were large enough to classify each brand as to type of fabric. Brands A, C, and D had similar thread count in both directions and could be classified as being percales. Brands B and E differed greatly in thread count between the warp and the filling direction. This difference indicated that they were of broadcloth construction. The mean warp thread count varied from 105 to 84. The mean of the filling thread count ranged from 80 to 59.

Yarn number. Variations of yarn number ranged from 44's to 38's in the warp yarns with Brand C having the highest number. Filling variations ranged from 40's to 30's. There was apparently no relationship between thread count of the fabrics and yarn number.

Fabric Serviceability

Indications of fabric serviceability were tested by determining colorfastness, tear resistance and resistance to wrinkling. Significant differences in the five brands were found in both tear strength and wrinkle recovery.

Colorfastness. All fabrics used were colorfast to the point that none were considered to be unacceptable for wear. Ratings for colorfastness are presented in detail in Table V.

Most fabrics were more colorfast to rubbing under dry conditions than under wet conditions. The range in colorfastness under dry condi-

TABLE V

RATINGS OF COLORFASTNESS

Brand	Rubbing		Light			Laundering
	Dry	Wet	20 hrs.	40 hrs.	60 hrs.	
A						(No appreciable change in color)
Blue	4.5	3.0	5	5	4	
Brown	4.5	3.0	5	5	5	
Pink	5.0	5.0	4	3	3	
Green	5.0	5.0	4	4	3	
B						
Blue	3.5	2.5	5	4	4	
Brown	4.1	2.5	5	5	4	
Pink	4.7	4.0	4	4	4	
Green	5.0	4.0	4	4	4	
C						
Blue	3.5	2.5	5	4	4	
Brown	4.5	2.5	5	4	4	
Pink	5.0	4.0	5	4	4	
Green	5.0	5.0	4	4	3	
D						
Blue	3.5	2.5	4	4	3	
Brown	3.2	2.5	4	4	3	
Pink	5.0	4.5	4	4	4	
Green	4.5	4.3	4	4	3	
E						
Blue	5.0	3.5	4	4	3	
Brown	5.0	4.0	4	4	3	
Pink	5.0	5.0	4	4	4	
Green	5.0	4.2	4	4	3	

tions was from a high of 5.0 to a low of 3.2. Under wet conditions fabrics ranged from 5.0 to 2.5.

All fabrics with the exception of the brown fabric in Brand A showed some degree of fading under carbon-arc light. After twenty hours of exposure the fabrics ranged from a high of 5 to a low of 4. The range after forty hours was the same, but with three more fabrics decreasing in colorfastness ratings. Following sixty hours of exposure the range varied from a high of 5 to a low of 3.

Comparison of all laundered samples with the original fabric showed no change in color. There was no color transfer to the swatches of multifiber cloth attached to the individual samples of fabric.

Tear strength. The original tear strength in both warp and filling directions is presented in Table VI. The warp tear strength varied

TABLE VI

TEAR STRENGTH AND WRINKLE RECOVERY AT THE ZERO INTERVAL

Brand	Tearing strength (pounds)		Wrinkle recovery (degrees)	
	Warp	Filling	Warp	Filling
A	2.24	1.56	117	118
B	2.83	1.77	101	103
C	2.26	2.05	125	127
D	1.77	0.86	118	116
E	2.62	1.42	84	84

from a high of 2.83 pounds to a low of 1.77 pounds. Variations of the filling tear strength were from 2.05 pounds to 0.86 pounds. With the exception of Brand D all fabrics had a warp tear strength of more than two pounds. Brand B had the highest resistance to tearing in the warp direction. Brands D and E showed low tear strength in the filling direction. An analysis of variance at the zero interval indicated both differences in brands and differences in direction to be significant factors for tear strength (Appendix C, Table XX).

Wrinkle recovery. The crease recovery angle of the five fabrics used in this study was measured at the zero interval (Table VI). Brand C had the highest warp wrinkle recovery angle measuring 125 degrees while Brand E had the low angle of 84 degrees. Brands C and E also had the highest and lowest filling wrinkle recovery angle respectively ranging from 127 degrees to 84 degrees. Analysis of variance at the zero interval indicated differences in the brands to be significant, but differences in direction to be insignificant (Appendix C, Table XXI).

III. ANALYSIS OF SERVICEABILITY OF LAUNDERED FABRICS

Serviceability of the fabrics after five launderings was tested by measuring dimensional change, tearing strength, and wrinkle recovery. Those fabrics with no softener added in the final rinse (control fabrics) and those fabrics to which a softener had been added (experimental fabrics) were also compared as to properties of serviceability. The trend indicated by these tests at the fifth washing interval could not be considered indicative of the results which might occur after more extended periods of laundering. However, differences in brands of fabric were apparent at this interval. Differences between the control fabrics and the experimental fabrics were also apparent at this interval.

Dimensional Change

All of the fabrics used in this study showed shrinkage following laundering in both the warp and the filling (Table VII). Brand B showed

TABLE VII

PER CENT SHRINKAGE AFTER FIVE LAUNDERINGS

Brand	Control		Experimental	
	Warp	Filling	Warp	Filling
A	1.4	0.9	1.2	0.7
B	3.5	1.9	3.2	1.7
C	0.7	1.8	0.7	1.8
D	1.3	0.5	0.9	0.3
E	2.2	1.7	2.3	1.6

the highest warp shrinkage (3.5 per cent) while Brand C had the lowest warp shrinkage (0.7 per cent). Those fabrics laundered with a fabric softener ranged in warp shrinkage from 3.2 per cent to 0.7 per cent with the same brands giving the high and low ratings as in the control fabrics. Shrinkage in the filling direction of the control fabrics ranged from 1.9 per cent to 0.5 per cent with Brand B showing the highest shrinkage and Brand D showing the least shrinkage. Shrinkage in the filling direction of the experimental fabrics ranged from 1.8 to 0.3 per cent with Brand C giving the highest dimensional change and Brand D giving the lowest change. Analysis of variance after five launderings indicated the only significant factor to be a difference in brands in the warp direction (Appendix D, Tables XXII and XIII). Graphic representation of dimensional change is presented in Figure 4.

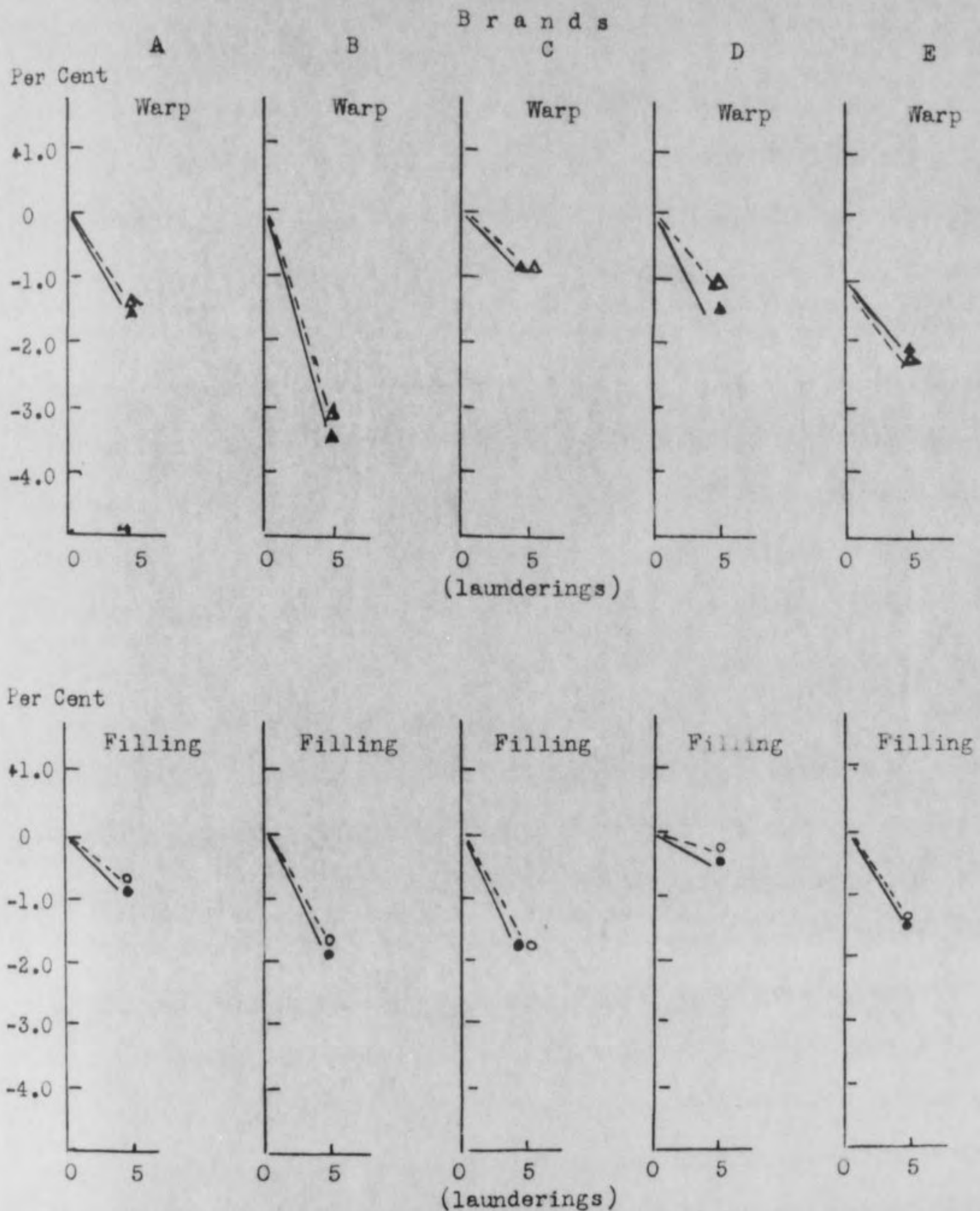

FIGURE 4

PERCENTAGE DIMENSIONAL CHANGE AFTER FIVE LAUNDERINGS

▲ ——— Warp after control treatment
△ - - - Warp after experimental treatment
● ——— Filling after control treatment
○ - - - Filling after experimental treatment

Tear Strength

Variations in tear strength after five launderings and the percentage change from the zero interval are presented in Table VIII. With the exception of Fabric A in the filling direction, all tear strength values increased from their original values. This increase in tear strength may be due to corresponding shrinkage of the fabrics. Variations in the control warp tear strength ranged from 3.12 pounds to 2.30 pounds while experimental fabrics varied from 3.27 to 2.41 pounds. Filling tear strength ranged from 2.11 pounds to 1.28 pounds for the control fabrics and from 2.16 to 1.35 pounds for the experimental fabrics. Brand B showed the highest warp tear strength for both control and experimental fabrics while Brand A had the lowest tear strength in the control fabrics and Brand C had the lowest tear strength in the experimental fabrics. Brand C and Brand D had the highest and lowest tear strength respectively in the filling direction. Percentage changes from the original tear strength values for the control fabrics in the warp direction varied from a high of 36.1 per cent to a low of 4.5 per cent. Experimental fabrics in the same direction ranged from 40.6 per cent to 18.8 per cent. Variations in percentage change in tear strength for the filling direction of the control fabrics ranged from 48.8 per cent to -1.9 per cent. Experimental fabrics for the filling direction varied from 90.8 per cent to 3.2 per cent. An analysis of variance of tear strength indicated that the following were significant for the:

A. Fifth interval
   1. The treatments in the warp direction (Appendix D, Table XXIV).

   2. The brands in the filling direction (Appendix D, Table XXV).

B. Zero-five interval

1. The brands (Appendix E, Tables XXVII-XXXI).

Graphic illustrations of changes in tear strength are presented in Figure 5.

Wrinkle Recovery

Variations in wrinkle recovery after five launderings are presented in Table IX. Changes from the original wrinkle recovery values are shown in Figure 6. All fabrics decreased in the angle of wrinkle recovery. The angle of wrinkle recovery in the warp direction varied from 106 degrees to 75 degrees for the control fabrics. Those fabrics laundered with a fabric softener ranged from 114 degrees to 80 degrees. The filling direction of the control fabrics ranged from 117 degrees to 78 degrees. Experimental fabrics in the same direction varied from 115 to 83 degrees. Brands C and D gave the highest results in both directions of control and experimental fabrics. The crease recovery angles in Brands B and E were never over 90 degrees. Percentage changes for the control fabrics in the warp direction ranged from a decrease of 4.1 per cent to 17.4 per cent. Experimental fabrics for the same direction varied from 3.4 per cent to 14.8 per cent. Percentage decreases in the filling direction of the control fabrics varied from 5.9 per cent to 15.8 per cent. Changes in the filling direction of the experimental fabrics varied from 1.2 per cent to 13.3 per cent. The analysis of variance for wrinkle recovery indicated the following variables were significant for the:

A. Fifth interval

1. The brands (Appendix D, Tables XXVI and XXVII).

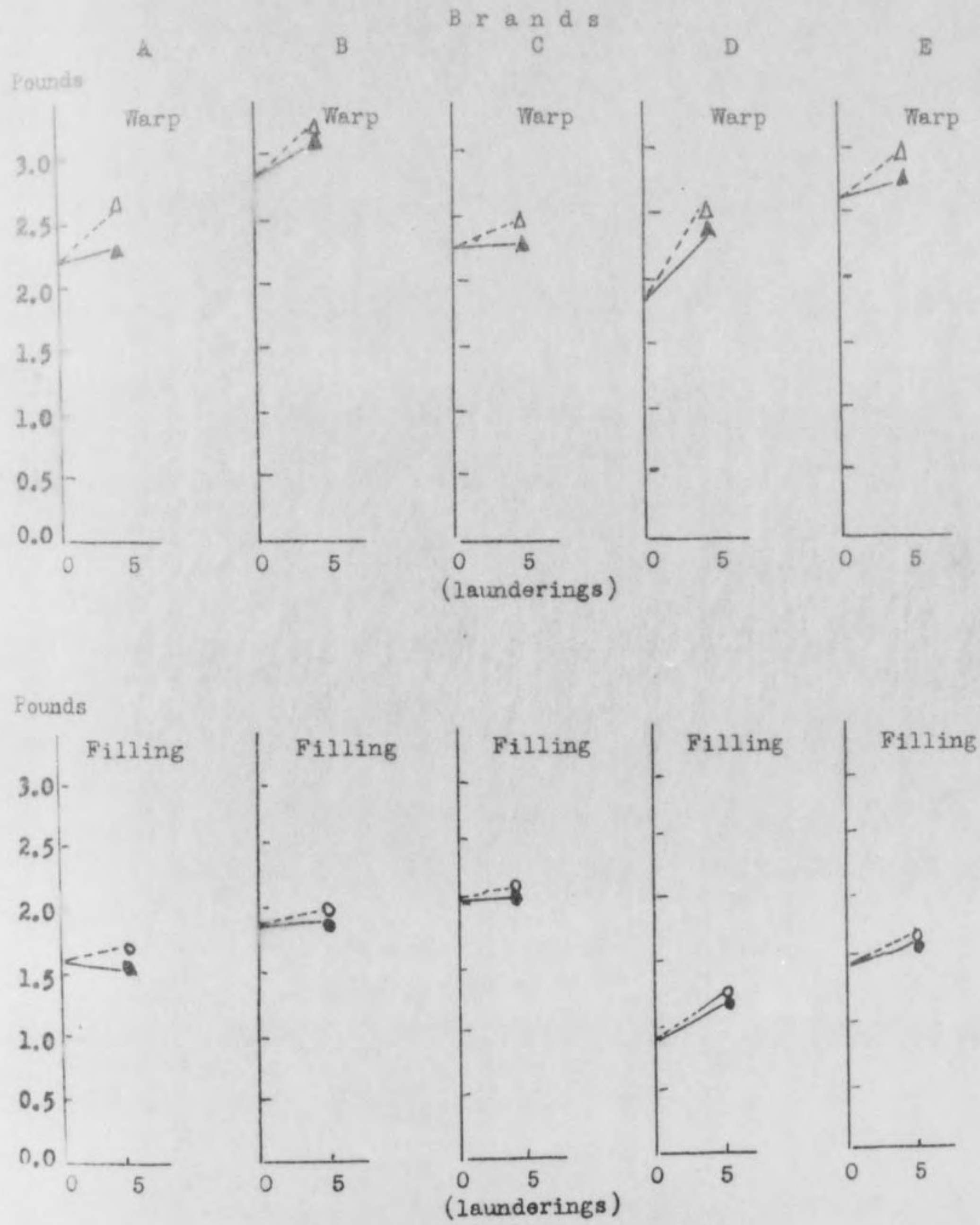

FIGURE 5

CHANGES IN TEAR STRENGTH AFTER FIVE LAUNDERINGS

▲——— Warp after control treatment
△- - - Warp after experimental treatment
●——— Filling after control treatment
○- - - Filling after experimental treatment

TABLE VIII

TEAR STRENGTH AFTER FIVE WASHINGS AND PERCENTAGE CHANGE FROM THE UNLAUNDERED FABRICS

Brands	Control				Experimental			
	Warp		Filling		Warp		Filling	
	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent
A	2.30	+2.2	1.53	-1.9	2.51	+12.0	1.61	+3.2
B	3.12	+10.2	1.84	+3.9	3.27	+15.5	1.95	+10.2
C	2.37	+4.8	2.11	+2.9	2.46	+8.8	2.16	+5.4
D	2.41	+36.1	1.28	+48.8	2.49	+40.6	1.35	+57.0
E	2.75	+4.5	1.55	+9.2	2.92	+11.4	1.66	+16.9

TABLE IX

WRINKLE RECOVERY AFTER FIVE WASHINGS AND PER CENT CHANGE FROM THE UNLAUNDERED FABRICS

Brand	Control				Experimental			
	Warp		Filling		Warp		Filling	
	Degrees	Per cent change	Degrees	Per cent change	Degrees	Per cent change	Degrees	Per cent change
A	98	-16.1	99	-15.8	102	-12.8	102	-13.3
B	86	-17.4	88	-14.3	86	-14.8	89	-13.3
C	106	-15.2	117	-7.8	112	-10.9	115	-9.4
D	113	-4.1	111	-5.9	114	-3.4	114	-1.8
E	75	-11.2	78	-6.6	80	-5.4	83	-1.2

TABLE VIII

TEAR STRENGTH AFTER FIVE WASHINGS AND PERCENTAGE CHANGE FROM THE UNLAUNDERED FABRICS

Brands	Control				Experimental			
	Warp		Filling		Warp		Filling	
	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent	Pounds	Per cent
A	2.30	+2.2	1.53	-1.9	2.51	+12.0	1.61	+3.2
B	3.12	+10.2	1.84	+3.9	3.27	+15.5	1.95	+10.2
C	2.37	+4.8	2.11	+2.9	2.46	+8.8	2.16	+5.4
D	2.41	+36.1	1.28	+48.8	2.49	+40.6	1.35	+57.0
E	2.75	+4.5	1.55	+9.2	2.92	+11.4	1.66	+16.9

TABLE IX

WRINKLE RECOVERY AFTER FIVE WASHINGS AND PER CENT CHANGE FROM THE UNLAUNDERED FABRICS

Brand	Control				Experimental			
	Warp		Filling		Warp		Filling	
	Degrees	Per cent change	Degrees	Per cent change	Degrees	Per cent change	Degrees	Per cent change
A	98	-16.1	99	-15.8	102	-12.8	102	-13.3
B	86	-17.4	88	-14.3	86	-14.8	89	-13.3
C	106	-15.2	117	-7.8	112	-10.9	115	-9.4
D	113	-4.1	111	-5.9	114	-3.4	114	-1.8
E	75	-11.2	78	-6.6	80	-5.4	83	-1.2

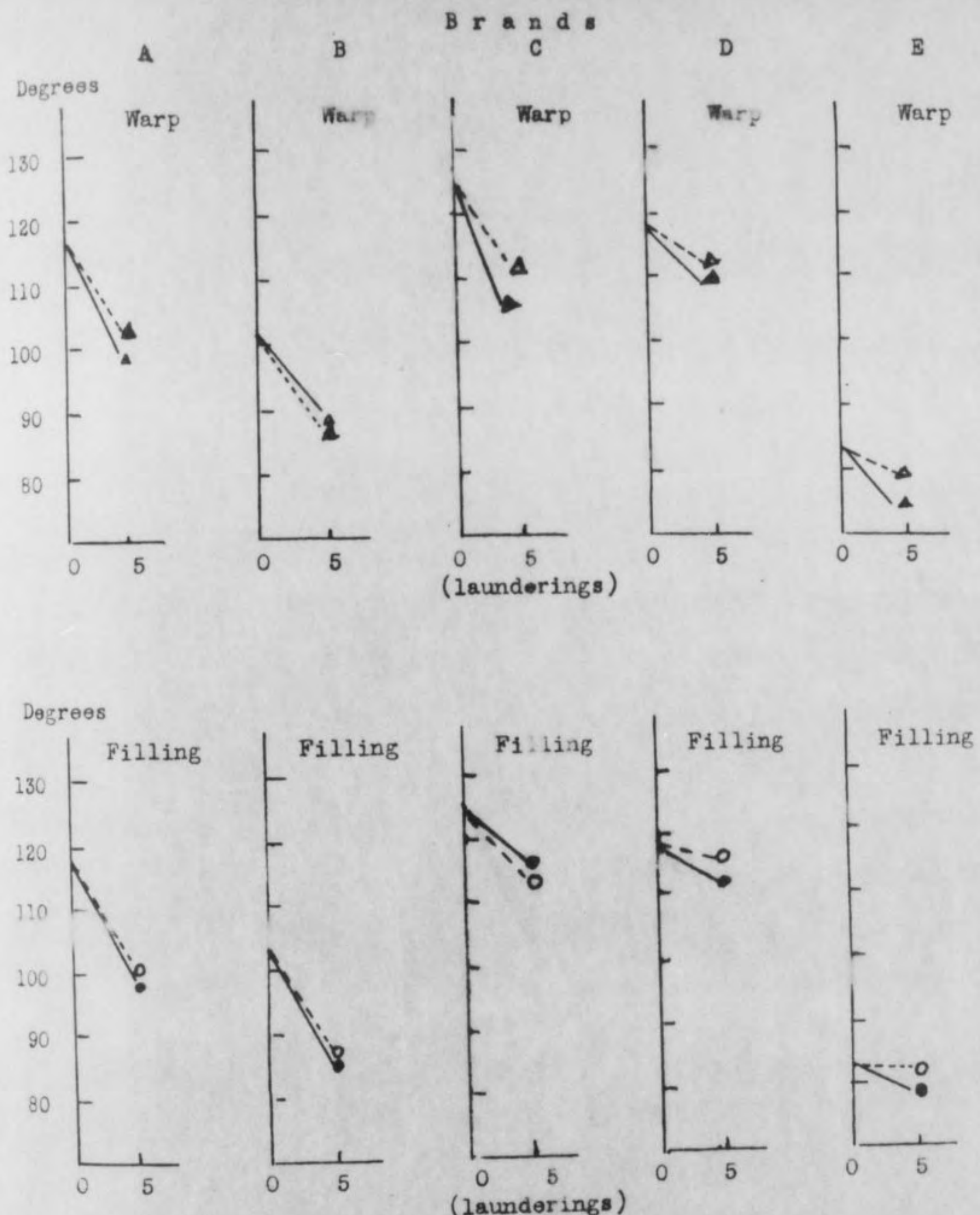

FIGURE 6

CHANGES IN WRINKLE RECOVERY AFTER FIVE LAUNDERINGS

▲——— Warp after control treatment
△ - - - Warp after experimental treatment
●——— Filling after control treatment
○ - - - Filling after experimental treatment

2. The treatments in the warp direction (Appendix D, Table XXVI).

B. Zero-five interval
1. The brands (Appendix E, Tables XXXII-XXXV).

2. The washing intervals (Appendix E, Tables XXXII-XXXV).

IV. EVALUATION OF THE SURFACE APPEARANCE OF LAUNDERED FABRICS AND GARMENTS

The garments were evaluated for surface appearance following each laundering interval. Two methods of evaluation were used--a subjective evaluation based on the standards established for this study and a less subjective method based on the Monsanto Three Dimensional Standards. In both methods of evaluation, numerical ratings were used to indicate the surface appearance of the fabric. Numerical ratings ranged from a high rating of 5 to a low rating of 1 with any rating above 3.0 being considered as acceptable for normal wear. The garments were evaluated subjectively by the investigator, the students wearing the garments and by a panel of three persons. The evaluations of the author and of the students were used to indicate problems likely to be of concern to the judging panels. Since these ratings were likely to be affected by familiarity with the purposes of the study, they were not considered to be valid for statistical analysis. The evaluations using the Monsanto Standards were also made by a panel of three persons. The data from both methods were interpreted statistically using the analysis of variance. In order to eliminate initial differences existing in the garments, the analysis was used to test the differences between these ratings given the unlaundered garments (zero interval) and the ratings given the same garments following each laundering interval.

Subjective Evaluation

Since the rating the surface appearance of a garment is based largely on personal standards, the subjective evaluation was considered to be a reliable measurement of consumer satisfaction. Blouses were observed under the controlled conditions established in the procedure. Blouses representing the extremes of the numerical rating scale were available for comparison during the evaluation periods.

Ratings were made on the garments as a whole and also on individual parts of the blouse. Areas of the blouse which were studied were the collar, blouse front, back yoke, blouse back, armscye and the sleeve cuff. Evaluations on parts of the blouse were of value in determining those areas most affected by no ironing and in assuring a more accurate rating of the garment as a whole.

Ratings of parts of the blouse. Conclusions of the subjective evaluation conducted by the author indicated that the blouse yoke and the sleeve cuff usually received the highest ratings and were more easily rated numerically. Rating of such areas as the collar, blouse front and the armscye were difficult because of slight variations in garment construction. In addition to the slight differences in garment construction, the lack of adaptability of the fabrics when easing was necessary and the crease lines from the folding of the material on the bolt may have affected ratings of the garments. Following the first two laundering intervals blouses in Brands C and E were easily recognized. Brand E was consistently poor in appearance while Brand C maintained the best appearance.

Results of mean numerical ratings of the three judges on the parts of the blouse indicated the following factors to be apparent: (1) there were variations in the ratings given parts of the garments; (2) there were variations in ratings at the different washing intervals and (3) there were differences in the fabrics used in this study. Table X shows the results of laundering on the mean results of areas of the blouse.

TABLE X

MEAN OF RATINGS GIVEN AREAS OF THE BLOUSES AT EACH OF THE WASHING INTERVALS

Washing interval	Areas of the blouse					
	Collar	Front	Yoke	Back	Armscye	Cuff
0	3.93	3.95	4.19	3.90	3.81	4.40
1	2.76	2.43	3.08	2.50	2.69	3.27
2	2.70	2.45	3.22	2.53	2.85	3.26
3	2.78	2.43	3.10	2.50	2.84	3.25
4	2.84	2.46	3.33	2.67	2.79	3.31
5	2.63	2.28	3.25	2.53	2.78	3.18
Total mean of all ratings	2.94	2.67	3.36	2.77	2.96	3.44

The yoke and the sleeve cuff consistently received the highest ratings on parts of the blouse. This result was expected since the hanging of the garments during drying permitted these areas to dry relatively free of folds. The collar, blouse front and blouse back were similar to each other in mean ratings, but were judged to be poorer in surface appearance. On the basis of the standards for numerical ratings all areas of the blouse except the yoke and the cuff would necessitate "touching up" with an iron to be acceptable for wear. Although differences in the surface appearance of each part of the blouse following the first laundering were great, variations during subsequent washing intervals varied little from the results of the first washing interval.

Table XI shows the mean variations of ratings on areas of the blouse among the several brands tested. Control garments were recorded apart from the experimental garments.

TABLE XI

MEAN OF RATINGS GIVEN AREAS OF THE BLOUSES OF EACH BRAND ACCORDING TO TREATMENT

Brand	Areas of the blouse						Total
	Collar	Front	Yoke	Back	Armscye	Cuff	Mean
A							
Control	3.23	3.00	3.98	3.07	3.07	3.87	3.37
Experimental	3.07	3.00	3.02	3.05	3.15	3.73	3.17
B							
Control	2.77	2.27	3.27	2.45	2.73	3.38	2.81
Experimental	2.70	2.27	3.53	2.52	1.53	3.25	2.63
C							
Control	3.73	3.43	4.25	3.57	3.93	4.32	3.87
Experimental	3.93	3.58	4.42	3.78	4.01	4.37	4.02
D							
Control	3.27	2.95	3.58	3.05	3.11	3.97	3.32
Experimental	3.35	2.98	3.65	3.17	3.35	3.87	3.34
E							
Control	1.67	1.52	2.07	1.58	1.78	1.90	1.75
Experimental	1.70	1.45	2.02	1.48	1.55	1.80	1.67

Brands A, C and D received total mean ratings which were considered to be satisfactory for wearing while Brands B and E were judged to be unsatisfactory. The yoke and the sleeve cuff of Brand C received the highest mean ratings during the entire study.

Ratings on the blouse as a whole. Evaluations of the surface appearance of the total garment were interpreted statistically. The main effects which were studied in the analysis were differences in ratings of brands, colors, treatments and judges. The first three of these effects were measured to test the established null hypotheses. Differences in the ratings of the judges were tested to be sure that personal bias had not affected the results.

The three judges who rated the garments by the subjective method gave different mean ratings at each interval; Judge 2 consistently gave the lowest ratings after the zero interval while Judges 1 and 3 gave ratings similar to each other but higher than those of Judge 2. Mean ratings at each laundering interval are presented in Table XII. Statistical analysis of these differences from the original rating indicated that there was a difference among the judges at the zero-one interval. During subsequent intervals these differences were not significant (Appendix F).

TABLE XII

MEAN RATINGS OF JUDGES AT EACH WASHING INTERVAL
SUBJECTIVE EVALUATION

Judge	Washing interval					
	0	1	2	3	4	5
1	3.65	2.51	2.65	2.55	2.75	2.95
2	3.70	2.10	2.15	2.52	2.35	2.10
3	4.57	2.40	2.92	2.80	3.08	2.75

Results of the mean ratings of the subjective evaluations of each brand at each washing interval are presented in Table XIII. All of the

TABLE XIII

MEAN RATINGS OF BLOUSES OF EACH BRAND AT EACH WASHING INTERVAL SUBJECTIVE EVALUATION

Brand	Interval					
	0	1	2	3	4	5
A	4.42	2.88	3.04	3.17	3.08	2.92
B	3.83	2.08	2.33	2.25	2.38	2.22
C	4.79	3.38	3.54	3.46	3.92	3.62
D	4.08	2.62	2.87	3.12	3.08	3.00
E	3.54	1.00	1.08	1.12	1.17	1.21
Total mean	4.13	2.39	2.58	2.62	2.72	2.60

blouses decreased in ratings of surface appearance following the first washing interval. The total mean results show that the greatest differences occurred after the first laundering and that the lowest ratings for each brand were given at this time. This may have been influenced by the fact that the judges had not rated unpressed garments prior to this interval and were more critical of the surface appearance. In the following intervals it is possible that their standards had adjusted to accept an unpressed garment and they could look for specific differences among the blouses. Brand C was the only group of garments rated as being satisfactory for wear at the first interval. During the subsequent washing intervals Brand C remained the most satisfactory of the five brands tested. The surface appearance of Brands A and D were rated as being satisfactory for three of the five laundering intervals. Brands B and E were rated as being unsatisfactory in surface appearance for all of the washing intervals. Statistical analysis of the data indicated that with the exception of the last laundering interval differences in the brands were significant (Appendix F).

Variations in the effect of color upon the surface appearance were evident at each of the evaluation periods. Blouses constructed from the dark fabrics ranged from an initial rating of 4.35 to a low rating of 2.53. Pastel colors ranged from a high rating of 3.92 to a low of 2.25. In both cases--pastel colors and dark colors--the lowest ratings were given at the first laundering interval. Results of variations are given in Table XIV. Statistical interpretation of the differences of the colors showed such variations not to be significant for each of the five washing intervals (Appendix F).

TABLE XIV

MEAN RATINGS OF COLOR AT EACH WASHING INTERVAL
SUBJECTIVE EVALUATION

Color	Washing interval					
	0	1	2	3	4	5
Pastel	3.92	2.25	2.48	2.48	2.48	2.60
Dark	4.35	2.53	2.67	2.77	2.97	2.73

Although there were variations between the ratings given the control garments and the ratings given the experimental garments, they were not considered to be significant at any of the laundering intervals (Appendix F).

Table XV shows the variations of the mean ratings between the control and the experimental garments. The greatest variation occurred at the third interval and this was only a difference of 0.19.

TABLE XV

MEAN RATINGS OF TREATMENTS AT EACH WASHING INTERVAL
SUBJECTIVE EVALUATION

Treatment	Washing interval					
	0	1	2	3	4	5
Control	4.15	2.35	2.62	2.52	2.77	2.52
Experimental	4.11	2.43	2.53	2.73	2.68	2.68

Non-Subjective Evaluations

Non-subjective evaluations of the surface appearance of the fabrics were evaluated using the Monsanto Three Dimensional Standards. Numerical ratings were based on comparison of the back of the blouse with plastic replicas of wrinkled fabric. Decisions made during this method of evaluation were expected to give a more accurate judgment of surfaces since they were not affected by the appearance of the garment. Evaluations of the author showed this method to be more objective since it was easier to rate the fabrics when there was an actual example for each numerical rating. However, the Monsanto Standards still involved a personal decision on the part of each judge. The data from these evaluations were analyzed statistically using the same effects as in the subjective evaluations.

Differences in judges. Differences in the mean ratings of the three judges are presented in Table XVI. Judges 2 and 3 gave higher ratings than judge 1 at the final four laundering intervals. Statistical analysis of the differences among the judges in mean ratings were significant at the third, fourth, and final washing interval (Appendix G).

TABLE XVI

MEAN VALUES OF RATINGS OF JUDGES AT EACH WASHING INTERVAL MONSANTO EVALUATION

Judge	Washing interval					
	0	1	2	3	4	5
1	4.70	2.80	2.72	2.55	2.42	2.42
2	4.58	2.75	2.88	3.25	3.65	3.25
3	4.70	3.30	3.35	3.10	3.30	3.18

Differences in brands. Results of the mean ratings of the brands according to the Monsanto method are presented in Table XVII.

TABLE XVII

MEAN RATINGS OF BLOUSES OF EACH BRAND AT EACH WASHING INTERVAL MONSANTO EVALUATION

Brand	Washing interval					
	0	1	2	3	4	5
A	4.46	3.21	2.96	3.12	3.33	3.38
B	4.83	2.96	2.83	2.79	2.88	2.79
C	5.00	3.54	3.67	3.80	3.83	3.79
D	5.00	3.79	3.75	3.62	3.88	3.67
E	4.00	1.25	1.71	2.75	1.70	1.54
Total mean	4.46	2.95	2.98	2.97	3.12	3.02

All of the garments decreased in surface appearance following the first washing interval. The total mean results show that the greatest differences were between the zero and the first interval. Variations among the other intervals were slight up through the fifth interval. Brands A, C and D received satisfactory ratings in each of the laundering intervals. Although both Brand B and Brand E were rated lower in surface appearance, only Brand E was "poor" in all of the washing intervals. Statistical analysis of the data indicated differences in brands were significant except for the second washing interval (Appendix G).

Differences in color. Variations in the effect of color upon the surface appearance of the fabrics were apparent at each washing interval. Blouses of the dark colors ranged from an initial rating of 4.07 to a low rating of 3.20. Pastel colors ranged from 4.60 to 2.57. After the first laundering interval the dark colors were always rated higher in surface appearance than the pastel colors. Results of variations of mean scores are presented in Table XVIII. Statistical analysis indicated differences between the mean ratings of the dark garments and the mean ratings of the pastel garments to be significant for the first, and fourth laundering intervals. They were not considered to be important at the other washing intervals (Appendix G).

TABLE XVIII

MEAN VALUES OF RATINGS OF COLOR AT EACH WASHING INTERVAL
MONSANTO EVALUATION

Color	Washing interval					
	0	1	2	3	4	5
Pastel	4.60	2.58	2.57	2.71	2.82	2.87
Dark	4.07	3.32	3.40	3.22	3.43	3.20

Differences in treatments. Although there were variations between the ratings of the control garments and the experimental garments, they were not considered to be significant (Appendix G). Table XIX shows the differences of the mean ratings between the control and the experimental garments at each washing interval. At the first three washing intervals the experimental garments were rated slightly higher than the control garments, but this was not true in the last two launderings.

TABLE XIX

MEAN RATINGS OF TREATMENTS AT EACH WASHING INTERVAL
MONSANTO EVALUATION

Treatment	Washing interval					
	0	1	2	3	4	5
Control	4.68	2.88	2.92	2.92	3.13	3.13
Experimental	4.63	2.98	3.05	3.02	3.12	2.93

Comparison of Evaluation Methods

The mean scores of each main effect between the subjective evaluation and the non-subjective evaluations were compared. In all cases mean numerical ratings according to the Monsanto Standards were higher than those same ratings according to the subjective method. Evaluation of the garments by the subjective method showed no significant differences in the ratings of the dark blouses and the ratings of the pastel blouses. Evaluations using the Monsanto Standards indicated significant differences in color at two washing intervals.

CHAPTER V

SUMMARY

Summary

The use of cotton as a wash and wear fabric has become widespread in the textile industry. Textile manufacturers have obtained wrinkle-free properties in cotton by various means, but mainly by the addition of resin treatments. Due to differences in the effectiveness of the finishes used, the degree of satisfaction of wash and wear cottons available to the consumer would be expected to vary in quality. This quality of the fabric would involve the initial properties influencing the appearance and performance of the fabric as well as the ability of the fabric to maintain those properties following laundering.

The objectives of this study were (1) to evaluate the maintenance of the wash and wear characteristics in five selected brands of cotton fabrics and, (2) to compare the degree to which a selected fabric softener (distearyl dimethyl ammonium chloride) affected the wash and wear characteristics in those same brands of cotton fabrics. In order to test such objectives the following null-hypotheses were established:

1. There is no significant difference in the surface appearance of the five brands of cotton fabric tested.
2. There is no significant difference in the surface appearance of the fabrics treated with a fabric softener and the control garments.
3. There is no significant difference between the surface appearance of the dark and the pastel colors.

Those brands selected for the study were cotton of broadcloth or percale construction, varying in price. All were labeled or designated as being wash and wear fabrics. Although many factors were considered in the selection of a brand, availability in the four colors--navy, brown, pink and green--was the most important factor.

Forty blouses were constructed from the wash and wear fabrics. The style of the pattern chosen was a shirt-type blouse with roll-up sleeves and a back yoke. Attempts were made during the construction to achieve a uniform appearance by having the several operators follow the same general procedures. The garments were worn for a period of eight hours after which they were laundered. This was repeated through five washing intervals. Those blouses designated as control garments were laundered according to the standardized procedure while those blouses designated as experimental garments had a fabric softener added to the final rinse. Following each laundering interval the blouses were evaluated by both a subjective and non-subjective method.

Prior to laundering, the fabrics were tested to determine the similarities and the differences among the five brands. All of the cottons were similar to each other in staple length, twist and weight per square yard. All fabrics were colorfast to rubbing, light and laundering. Differences were evident in thread count, yarn number, tear strength and wrinkle recovery. The variations in thread count and yarn number may have been influenced by the differences in cloth construction. Brands B and E were broadcloth while Brands A, C, and D were percale. Variations in tear strength among the brands were considered to be significant. Warp tear strength was significantly greater than in the filling tear strength. Brand D showed low tear strength in both the warp and the filling directions. The angle of wrinkle recovery also varied significantly among the brands. Brand C had the highest wrinkle recovery angle in both the warp and the filling directions. Brands A, B and D were similar to each other while Brand E had the lowest wrinkle recovery angle in both directions.

Following the five launderings the dimensional change, tear strength and wrinkle recovery were measured. Samples for these tests were cut from a square of fabric which was laundered with the garments in both control and experimental groups. Differences among the brands were noted in each test. Although shrinkage occurred in all of the brands, only Brands B and E exceeded the 2% level. Variations among brands in dimensional change were considered to be important. Tear strength values increased in most cases following laundering. The use of a fabric softener consistently produced a greater tear strength which was considered to be significantly different from the control fabrics. Brand B had the highest tear strength in the warp direction in both the control and experimental fabrics while Brand C had the highest tear strength in the filling direction. Brand D seemed to have a very low tear strength in the filling direction. Wrinkle recovery following five laundering treatments decreased in all of the fabrics. Brand C which had possessed the highest original wrinkle recovery remained high while Brand D was very similar to it at the final interval. Brands A, B and E were considerably lower in the angle of wrinkle recovery indicating that some of the resin application may have no longer been in evidence.

The surface appearance of the blouses was evaluated after each of the five washing intervals by two methods of evaluation. The surface appearance of each blouse as a whole and of the individual areas of the blouse was appraised by a subjective method based on standards devised for this study. Three judges viewed the garments under controlled conditions and gave them numerical ratings ranging from a high of 5 to a low of 1. Surface appearance of the fabric in the back of the blouse was evaluated using plastic samples of wrinkled fabrics as standards. Three different judges evaluated the garments by this method. Numerical scores ranged from a high of 5 to a low of 1.

The data from both these methods of evaluation were analyzed statistically using the analysis of variance. So that initial differences existing in the garments could be eliminated, the analysis was used to test the differences between the ratings at the zero interval and each washing interval. In this analysis four variables were studied--judges, brands, colors and treatments. First and second order interactions were also determined. The programming of the data was done by the Remington Rand 1105. A program was written in the language of the machine by a series of coded statements known as iteration statements. The iteration statements allowed for more efficient use of machine time and energy by speeding up all the statements within the program which were of a repetitious nature.

Results of the analysis on both sets of data indicated that in some cases there was a difference in the mean ratings of the judges. It is possible that results of the other three main effects could have been influenced by this fact. Differences in the surface appearance of the blouses were considered significant. Brand C was consistently rated as having the best surface appearance while Brands B and E were poor in surface appearance. Color was a determining factor in the surface appearance of the garments. The dark blouses received higher ratings than the pastel blouses. Results of this study indicated that the addition of the selected fabric softener had no significant effect on the surface appearance of the blouses. None of the first or second order interactions were considered to be significant. A comparison of the two methods of evaluation used showed that numerical ratings by the non-subjective method of evaluation were higher than those of the subjective method.

Conclusions

The results of this study indicated the following conclusions:

Some significant differences were apparent in the serviceability features of the five brands of fabric. However, the results from this number of laundering intervals were not considered representative of the performance of such fabrics in actual consumer use.

There were differences in the surface appearance of the five brands of fabric tested; therefore, the first null-hypothesis was not accepted. Brand C was judged to be the fabric with the highest wash and wear properties. Brands B and E were considered to be unacceptable as wash and wear fabrics.

The addition of the fabric softener, distearyl dimethyl ammonium chloride, had no effect on the surface appearance of the fabrics; therefore, the second null-hypothesis was not rejected.

The ratings of the dark fabrics were higher than ratings of the pastel fabrics; therefore, the third null-hypothesis was not accepted. The third null-hypothesis could not be rejected when considering surface appearance of the blouse according to subjective evaluations.

Recommendations

Recommendations for further study are that similar experimentation be carried over a greater number of washing intervals. For such a study it is recommended that (1) color be eliminated as a variable; (2) the experimentation be applied to fabrics with known resin finishes; (3) the comparison involve different brands of softeners available to the consumer and (4) evaluation of the surface appearance be limited to use of the Monsanto Standards.

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APPENDIXES

APPENDIX A

RATING CARDS USED FOR SUBJECTIVE EVALUATION

Code No.	________________	Code No.	________________
Collar	_____	Name	________________
Front	_____	Date	________________
Yoke	_____	Hours	________________
Back	_____	Activity	________________
Sleeve (Armscye)	_____		________________
Sleeve (Cuff)	_____	Comments	________________
Total (do not fill in)	_____		________________
			________________
Average	_____		________________
Blouse in general	_____		

FIGURE 7

FORMAT FOR SUBJECTIVE EVALUATION CARD

Rate by numbers only (5, 4, 3, 2, 1). Five (5) represents the highest score while one (1) indicates the lowest score.

5 - excellent -- free from wrinkles; one would have no objections to wearing it.

4 - very good -- wrinkles present, but the appearance is still above average.

3 - good -- wrinkles present, but of such dimension that the effect is satisfactory.

2 - fair -- wrinkling to such a degree that it gives the blouse a bad appearance.

1 - poor -- excessive wrinkling; one would object to wearing this garment.

FIGURE 8

STANDARDS FOR SUBJECTIVE EVALUATION

APPENDIX B

ANALYSIS OF VARIANCE PROGRAM FOR

REMINGTON RAND UNIVAC 1105

```
       N 0025   Y 0360   Z 0201   S 0100   W 0800                    H

0001   *39S,0,10000*                                                 F

0100   CAGLE INPUT                                                   F
       83,N3,1,1,120,                                                F

0083   Y(N3+240):YN3-Y(N3+120)                                       F

       68,N6,0,120,240,                                              F
0013   N5:N6                                                         F
       N2:1                                                          F
       N3:1+N6                                                       F

       N4:2                                                          F
       N21:0                                                         F
0020   ZN2:YN3+Y(N3+1)+Y(N3+2)+Y(N3+6)+Y(N3+7)+Y(N3+8)               F

       N2:N2+1                                                       F
       N3:N3+3                                                       F
       NO:N4                                                         F
       N4:N4+1                                                       F
        GNO                                                          F

0002   G20                                                           F
0003   N3:N3+54                                                      F
       G20                                                           F
0004   G20                                                           F
0005   N3:N3-54                                                      F
       G20                                                           F
0006   G20                                                           F
0007    N21:N21+1                                                    F
       N4:N4-4                                                       F
        G 3 IF 5 V N21                                               F

       N4:N4+4                                                       F
       N3:N3+54                                                      F
       G20                                                           F
0008   G20                                                           F
0009   22,NO,1,4,17,                                                 F
0024   N1:21+NO/2

        ZN1:ZNO+Z(NO+2)
```

APPENDIX B (Continued)

```
0022    Z(N1+1):Z(NO+1)+Z(NO+3)                    F
        Z31:0                                      F

        10,NO,21,1,30,                             F
0010    Z31:Z31+ZNO                                F
        Z31:Z31xZ31/120                            F
        Z151:0                                     F
        Z0:0                                       F
        11,NO,21,2,29,                             F
0012    Z0:Z0+ZNO                                  F
0011    Z151:Z151+Z(NO+1)                          F
        Z32:(Z0xZ0)+(Z151xZ151)                    F
        Z32:(Z32/60)-Z31                           F

        Z0:0                                       F
        15,NO,21,1,22,                             F
0016    Z0:Z0+ZNO                                  F
        Z152:Z152+Z(NO+2)                          F
        Z153:Z153+Z(NO+4)                          F
        Z154:Z154+Z(NO+6)                          F
0015    Z155:Z155+Z(NO+8)                          F
        Z33:Z0xZ0                                  F
        21,NO,152,1,155,                           F
0021    Z33:Z33+ZNOxZNO                            F
        Z33:(Z33/24.)-Z31                          F

        Z152:0                                     F
        Z153:0                                     F
        35,NO,1,4,17,                              F
0029    N1:NO+2                                    F
        Z152:Z152+ZNO+Z(NO+1)                      F
0035    Z153:Z153+ZN1+Z(N1+1)                      F
        Z34:(Z152xZ152)+(Z153xZ153)                F
        Z34:(Z34/60.)-Z31                          F

        Z35:0                                      F
        17,N3,N5+1,1,N5+3,                         F
0019    Z0:0                                       F
        N10:N3+117                                 F
        18,N2,N3,3,N10,                            F
0018    Z0:Z0+YN2                                  F
0017    Z35:Z35+Z0xZ0                              F
        Z35: (Z35/40)-Z31

        Z0:0                                       F
        Z201:Z31+Z232+Z233                         F
```

APPENDIX B (Continued)

```
         23,N0,21,1,30,                                F
0023     Z0:Z0+ZN0xZN0                                 F
         Z36:(Z0/12)-Z201                              F

         Z0:0                                          F
         25,N0,1,2,19,                                 F
0087     Z159:ZN0+Z(N0+1)                              F
0025     Z0:Z0+Z159xZ159                               F
         Z37:(Z0/12)-(Z31+Z33+Z34)                     F

         Z0:0                                          F
         26,N0,1,1,4,                                  F
0088     Z160:0.                                       F
         28,N1,0,4,16,                                 F
0028     Z160:Z160+Z(N0+N1)                            F
0026     Z0:Z0+Z160xZ160                               F
         Z38:(Z0/30)-(Z31+Z32+Z34)                     F

         30,N3,N5+1,1,N5+6,                            F
0089     Z0:0                                          F
         N10:N3+114                                    F
         31,N2,N3,6,N10,                               F
0031     Z0:Z0+ YN2                                    F
0030     Z162:Z162+Z0xZ0                               F
         Z39:(Z162/20)-(Z31+Z32+Z35)                   F

         32,N3,N5+1,1,N5+3,                            F
0071     Z0:0                                          F
         Z201:0.                                       F
         33,N2,N3,3,N3+57,                             F
0034     Z201:Z201+Y(N2+60)                            F
0033     Z0:Z0+YN2                                     F
0032     Z163:Z163+(Z0xZ0)+(Z201xZ201)                 F
         Z40:((Z163)/20.)-(Z31+Z34+Z35)                F

         36,N3,N5+1,12,N5+49,                          F
0041     Z0:0                                          F
         37,N2,N3,3,N3+9,                              F
0037     Z0:Z0+YN2+Y(N2+60)                            F
0036     Z164:Z164+Z0xZ0                               F
         77,N3,N5+2,12,N5+50,                          F
0027     Z0:0                                          F
         38,N2,N3,3,N3+9,                              F
0038     Z0:Z0+YN2+Y(N2+60)                            F
0077     Z164:Z164+Z0xZ0                               F
         39,N3,N5+3,12,N5+51,                          F
0072     Z0:0                                          F
         40,N2,N3,3,N3+9,                              F
```

APPENDIX B (Continued)

```
0040    ZO:ZO+YN2+Y(N2+60)                          F
0039    Z164:Z164+ZOxZO                             F
        Z41:(Z164/8)-(Z31+Z33+Z35)                  F

        ZO:0                                        F
        42,NO,1,1,20,                               F
0042    ZO:ZO+ZNOxZNO                               F
        Z42:(ZO/6)                                  F
        55,NO,31,1,38,                              F
0055    Z42:Z42-ZNO                                 F
        Z42:Z42+Z35                                 F

        43,N3,N5+1,12,N5+49,                        F
0073    ZO:0                                        F
        44,N2,N3,6,N3+6,                            F
0044    ZO:ZO+YN2+Y(N2+60)                          F
0043    Z165:Z165+ZOxZO                             F
        45,N3,N5+4,12,N5+52,                        F
0074    ZO:0                                        F
        46,N2,N3,6,N3+6,                            F
0046    ZO:ZO+YN2+Y(N2+60)                          F
0045    Z165:Z165+ZOxZO                             F
        47,N3,N5+2,12,N5+50,                        F
  67    ZO:0                                        F
        48,N2,N3,6,N3+6,                            F
0048    ZO:ZO+Y(N2)+Y(N2+60)                        F
0047    Z165:Z165+ZOxZO                             F
        49,N3,N5+5,12,N5+53,                        F
0065    ZO:0                                        F
        50,N2,N3,6,N3+6,                            F
0050    ZO:ZO+YN2+Y(N2+60)                          F
0049    Z165:Z165+ZOxZO                             F
        51,N3,N5+3,12,N5+51,                        F
0075    ZO:0                                        F
        52,N2,N3,6,N3+6,                            F
0052    ZO:ZO+YN2+Y(N2+60)                          F
0051    Z165:Z165+ZOxZO                             F
        53,N3,N5+6,12,N5+54,                        F
0076    ZO:0                                        F
        54,N2,N3,6,N3+6,                            F
0054    ZO:ZO+YN2+Y(N2+60)                          F
0053    Z165:Z165+ZOxZO                             F
        Z43:(Z165/4.)-(Z31+Z32+Z33+Z35+Z36+Z39+Z41)

        N10:N5+109                                  F
        56,N3,N5+1,12,N10,                          F
0078    ZO:0                                        F
        57,N2,N3,3,N3+9,                            F
```

APPENDIX B (Continued)

```
0057   Z0:Z0+YN2                                   F
0056   Z166:Z166+Z0xZ0                             F
       N10:N5+110                                  F
       58,N3,N5+2,12,N10,                          F
0079   Z0:0                                        F
       59,N2,N3,3,N3+9,                            F
0059   Z0:Z0+YN2                                   F
0058   Z166:Z166+Z0xZ0                             F
       N10:N5+111                                  F
       60,N3,N5+3,12,N10,                          F
0080   Z0:0                                        F
       61,N2,N3,3,N3+9,                            F
0061   Z0:Z0+YN2                                   F
0060   Z166:Z166+Z0xZ0                             F
       Z44:Z166/4                                  F
       Z44:Z44-(Z31+Z33+Z34+Z35+Z37+Z40+Z41)       F

       62,N3,N5+1,1,N5+6,                          F
0081   N4:N3+60                                    F
       Z0:0                                        F
       63,N2,N3,6,N3+54,                           F
0063   Z0:Z0+YN2                                   F
       Z167:Z167+Z0xZ0                             F
       Z0:0                                        F
       64,N2,N4,6,N4+54,                           F
0064   Z0:Z0+YN2                                   F
0062   Z167:Z167+Z0xZ0                             F
       Z45:(Z167/10)-(Z31+Z32+Z34+Z35+Z38+Z39+Z40) F

       N10:N5+120                                  F
       66,N3,N5+1,1,N10,                           F
0082   Z0:0                                        F
       Z0:Z0+YN3                                   F
0066   Z168:Z168+Z0xZ0                             F
       Z46:Z168-Z31                                F

       Z0:0                                        F
       84,N3,32,1,45,                              F
0084   Z0:Z0+ZN3                                   F
       Z47:Z46-Z0                                  F

       *42S,1,361,6,8*                             F

       N0:51+N6/6                                  F
       Z168:0                                      F
       69,N1,31,1,47,                              F
0070   Z(120+N1):0                                 F
       ZN0:ZN1                                     F
```

APPENDIX B (Continued)

```
0069    NO:NO+1                                         F
        NO:0                                            F

0068    N6:N6                                           F
        G 1 IF Z67 U 0                                  F

        Z125:Z107/68                                    F
        Z126:Z92                                        F
        Z127:Z93/4                                      F
        Z128:Z94                                        F
        Z129:Z95/2                                      F
        Z130:Z96/4                                      F
        Z131:Z97/4                                      F
        Z132:Z98                                        F
        Z133:Z99/2                                      F
        Z134:Z100/2                                     F
        Z135:Z101/8                                     F
        Z136:Z102/4                                     F
        Z137:Z103/8                                     F
        Z138:Z104/8                                     F
        Z139:Z105/2                                     F

        Z0:Z125+Z136+Z137+Z138+Z139                     F

        G 1 IF Z0 U 0                                   F

        86,NO,126,1,139,                                F
0086    Z(NO+14):ZNO/Z0                                 F

        85,NO,125,4,153,                                F
0085    TZNO  TZ(NO+1)  TZ(NO+2)  TZ(NO+3)              F
        99,NO,151,1,167,                                F
0099     ZNO:0.                                         F

        G100                                            FF
```

APPENDIX C

ANALYSIS OF VARIANCE ON RESULTS OF FABRIC SERVICEABILITY TESTS MADE ON UNLAUNDERED FABRICS

TABLE XX

ANALYSIS OF VARIANCE OF TEAR STRENGTH--ZERO INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	_F_ Values	_F_ .95	_F_ .99
Brands	4	2.12	0.53	7.07*	6.39	15.98
Direction	1	1.77	1.77	23.60**	7.71	21.20
Within cell variation	4	0.03	0.08			
Total	9	3.92				

TABLE XXI

ANALYSIS OF VARIANCE OF WRINKLE RECOVERY--ZERO INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	_F_ Values	_F_ .95	_F_ .99
Brands	4	2192.2192	548.0548	232.21**	6.39	15.98
Direction	1	0.7209	0.7209	0.30	7.71	21.20
Within cell variation	4	9.4406	2.3602			
Total	9	2202.3807				

* Significant at .95

** Significant at .99

APPENDIX D

ANALYSIS OF VARIANCE ON RESULTS OF FABRIC SERVICEABILITY

TESTS MADE ON LAUNDERED FABRICS

TABLE XXII

ANALYSIS OF VARIANCE OF WARP DIMENSIONAL CHANGE--FIFTH INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	9.030	2.2575	56.43**	6.39	15.98
Treatments	1	0.006	0.0015	00.38	7.71	21.20
Within cell variation	4	0.188	0.0470			
Total	9	9.24				

TABLE XXIII

ANALYSIS OF VARIANCE OF FILLING DIMENSIONAL CHANGE--FIFTH INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	3.34	0.835	3.93	6.39	15.98
Treatments	1	0.03	0.030	0.01	7.71	21.20
Within cell variation	4	0.85	0.212			
Total	9	4.22				

* Significant at .95

** Significant at .99

APPENDIX D (Continued)

TABLE XXIV

ANALYSIS OF VARIANCE OF WARP TEAR STRENGTH--FIFTH INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	0.049	0.0123	1.63	6.39	15.98
Treatment	1	0.962	0.962	12.83*	7.71	21.20
Within cell variation	4	0.003	0.0075			
Total	9	1.014				

TABLE XXV

ANALYSIS OF VARIANCE OF FILLING TEAR STRENGTH--FIFTH INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	0.832	0.208	27.01**	6.39	15.98
Treatment	1	0.018	0.018	2.34	7.71	21.20
Within cell variation	4	0.031	0.0075			
Total	9	0.881				

* Significant at .95

** Significant at .99

APPENDIX D (Continued)

TABLE XXVI

ANALYSIS OF VARIANCE OF WARP WRINKLE RECOVERY--FIFTH INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	1872.9340	468.2335	210.84**	6.39	15.98
Treatments	1	25.0684	25.0684	11.29**	7.71	21.20
Within cell variation	4	8.8832	2.2208			
Total	9	1906.8856				

TABLE XXVII

ANALYSIS OF VARIANCE OF FILLING WRINKLE RECOVERY--FIFTH INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	1834.2000	458.550	152.38**	6.39	15.98
Treatments	1	8.6320	8.632	2.87	7.71	21.20
Within cell variation	4	12.0397	3.009			
Total	9	1854.8717				

* Significant at .95

** Significant at .99

APPENDIX E

ANALYSIS OF VARIANCE ON RESULTS OF FABRIC SERVICEABILITY TESTS MADE AT THE ZERO-FIVE INTERVAL

TABLE XXVIII

ANALYSIS OF VARIANCE OF WARP TEAR STRENGTH (CONTROL FABRICS) ZERO-FIVE INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	0.1495	0.0374	0.46	6.39	15.98
Interval	1	1.0181	1.0181	1.18	7.71	21.90
Within cell variation	4	0.3436	0.0859			
Total	9	1.5112				

TABLE XXIX

ANALYSIS OF VARIANCE OF WARP TEAR STRENGTH (EXPERIMENTAL FABRICS) ZERO-FIVE INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Values	$F_{.95}$	$F_{.99}$
Brands	4	1.0814	0.2703	14.64*	6.39	15.98
Interval	1	0.3724	0.3724	2.01	7.71	21.20
Within cell variation	4	0.0738	0.0185			
Total	9	1.5276				

* Significant at .95

** Significant at .99

APPENDIX E (Continued)

TABLE XXX

ANALYSIS OF VARIANCE OF FILLING TEAR STRENGTH (CONTROL FABRICS)
ZERO-FIVE INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	*F* Values	$F_{.95}$	$F_{.99}$
Brands	4	1.3833	0.3458	7.83*	6.39	15.98
Interval	1	0.1392	0.1392	3.15	7.71	21.20
Within cell variation	4	0.1767	0.0442			
Total	9	1.6992				

TABLE XXXI

ANALYSIS OF VARIANCE OF FILLING TEAR STRENGTH (EXPERIMENTAL FABRICS)
ZERO-FIVE INTERVAL

Source	Degrees of Freedom	Sum of Squares	Mean Square	*F* Values	$F_{.95}$	$F_{.99}$
Brands	4	1.3481	0.3370	7.05*	6.39	15.98
Interval	1	0.2592	0.2592	5.42	7.71	21.20
Within cell variation	4	0.1915	0.0478			
Total	9	1.7988				

* Significant at .95

** Significant at .99

APPENDIX E (Continued)

TABLE XXXII

ANALYSIS OF VARIANCE OF WARP WRINKLE RECOVERY (CONTROL FABRICS)
ZERO-FIVE INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F values	F .95	F .99
Brands	4	1947.409	486.852	26.29**	6.39	15.98
Interval	1	459.819	459.819	24.83**	7.71	21.20
Within cell variation	4	74.060	18.515			
Total	9	2481.288				

TABLE XXXIII

ANALYSIS OF VARIANCE OF WARP WRINKLE RECOVERY (EXPERIMENTAL FABRICS)
ZERO-FIVE INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F values	F .95	F .99
Brands	4	1934.525	483.631	36.01**	6.39	15.98
Interval	1	270.993	270.993	20.18**	7.71	21.20
Within cell variation	4	53.726	13.432			
Total	9	2259.244				

* Significant at .95

** Significant at .99

APPENDIX E (Continued)

TABLE XXXIV

ANALYSIS OF VARIANCE OF FILLING WRINKLE RECOVERY (CONTROL FABRICS)
ZERO-FIVE INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F values	$F_{.95}$	$F_{.99}$
Brands	4	2077.858	519.464	29.17**	6.39	15.98
Interval	1	290.963	290.963	16.34**	7.71	21.20
Within cell variation	4	71.229	17.807			
Total	9	2440.050				

TABLE XXXV

ANALYSIS OF VARIANCE OF FILLING WRINKLE RECOVERY (EXPERIMENTAL FABRICS)
ZERO-FIVE INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F values	$F_{.95}$	$F_{.99}$
Brands	4	1870.915	467.729	21.77*	6.39	15.98
Interval	1	199.511	199.511	9.29*	7.71	21.20
Within cell variation	4	85.935	21.484			
Total	9	2164.593				

* Significant at .95

** Significant at .99

APPENDIX F

ANALYSIS OF VARIANCE ON SURFACE APPEARANCE

BY SUBJECTIVE EVALUATION

TABLE XXXVI

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-ONE INTERVAL SUBJECTIVE EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	*F* values
Color	1	.833	.833	.55
Brand	4	21.383	5.346	3.56**
Treatment	1	.133	.133	.09
Judge	2	11.817	5.908	3.93*
CxB	4	3.417	.854	.57
TxB	4	.117	.029	.02
CxT	1	1.633	1.633	1.09
CxJ	2	.817	.408	.27
TxJ	2	1.317	.658	.44
BxJ	8	8.767	1.096	.73
CxBxT	4	1.283	.321	
CxBxJ	8	3.933	.492	
BxTxJ	8	.933	.117	
CxTxJ	2	.117	.058	
Residual	68	34.967	.514	
Total	119			

*Significant at .95
**Significant at .99

APPENDIX F (Continued)

TABLE XXXVII

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-TWO INTERVAL SUBJECTIVE EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	*F* values
Color	1	1.875	1.875	1.57
Brand	4	29.750	7.438	6.23**
Treatment	1	.208	.208	.17
Judge	2	1.717	.858	.72
CxB	4	5.083	1.271	1.06
TxB	4	.417	.104	.09
CxT	1	.075	.075	.06
CxJ	2	.350	.175	.15
TxJ	2	.817	.408	.34
BxJ	8	6.700	.838	.70
CxBxT	4	.217	.054	
CxBxJ	8	2.567	.321	
BxTxJ	8	2.933	.367	
CxTxJ	2	.050	.025	
Residual	68	29.033	.427	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX F (Continued)

TABLE XXXVIII

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-THREE INTERVAL SUBJECTIVE EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	*F* values
Color	1	1.633	1.633	.62
Brand	4	28.883	7.221	2.76*
Treatment	1	.300	.300	.11
Judge	2	12.150	6.075	2.32
CxB	4	3.783	.946	.36
TxB	4	7.617	1.904	.73
CxT	1	.833	.833	.32
CxJ	2	.517	.258	.10
TxJ	2	.950	.475	.18
BxJ	8	5.267	.658	.25
CxBxT	4	3.583	.896	
CxBxJ	8	5.067	.633	
BxTxJ	8	3.133	.392	
CxTxJ	2	.117	.058	
Residual	68	43.467	.639	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX F (Continued)

TABLE XXXIX

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-FOUR INTERVAL SUBJECTIVE EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	F values
Color	1	.033	.033	.02
Brand	4	34.300	8.575	5.25**
Treatment	1	.300	.300	.18
Judge	2	.800	.400	.24
CxB	4	10.133	2.533	1.56
TxB	4	.033	.008	.00
CxT	1	.533	.533	.33
CxJ	2	1.867	.933	.57
TxJ	2	.800	.400	.24
BxJ	8	6.950	.869	.53
CxBxT	4	.133	.033	
CxBxJ	8	3.217	.402	
BxTxJ	8	4.117	.514	
CxTxJ	2	.267	.133	
Residual	68	37.317	.549	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX F (Continued)

TABLE XXXX

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-FIVE INTERVAL SUBJECTIVE EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	F values
Color	1	1.875	1.875	.68
Brand	4	23.667	5.917	2.14
Treatment	1	.408	.408	.15
Judge	2	10.717	5.358	1.94
CxB	4	1.667	.417	.15
TxB	4	1.633	.408	.15
CxT	1	.408	.408	.15
CxJ	2	1.050	.525	.19
TxJ	2	.817	.408	.15
BxJ	8	5.533	.692	.25
CxBxT	4	1.633	.408	
CxBxJ	8	6.533	.817	
BxTxJ	8	2.267	.283	
CxTxJ	2	1.617	.808	
Residual	68	29.967	.441	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX G

ANALYSIS OF VARIANCE ON SURFACE APPEARANCE

BY MONSANTO EVALUATION

TABLE XXXXI

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-ONE INTERVAL MONSANTO EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	*F* values
Color	1	11.408	11.408	5.67*
Brand	4	39.250	9.812	4.88**
Treatment	1	1.008	1.008	.50
Judge	2	5.817	2.908	1.44
CxB	4	3.550	.888	.44
TxB	4	2.950	.738	.37
CxT	1	.075	.075	.04
CxJ	2	.617	.308	.15
TxJ	2	1.817	.908	.45
BxJ	8	2.600	.325	.16
CxBxT	4	3.717	.929	
CxBxJ	8	2.300	.287	
BxTxJ	8	2.600	.325	
CxTxJ	2	1.500	.075	
Residual	68	26.93	.396	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX G (Continued)

TABLE XXXXII

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-TWO INTERVAL MONSANTO EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	*F* values
Color	1	3.675	3.675	1.00
Brand	4	17.717	4.429	1.20
Treatment	1	.408	.408	.11
Judge	2	.517	.258	.70
CxB	4	3.617	.904	.24
TxB	4	2.717	.679	.18
CxT	1	.408	.408	.11
CxJ	2	3.350	1.675	.45
TxJ	2	.317	.158	.43
BxJ	8	7.733	.967	.26
CxBxT	4	1.217	.304	
CxBxJ	8	9.233	1.154	
BxTxJ	8	8.433	1.054	
CxTxJ	2	1.017	.508	
Residual	68	45.23	.665	
Total	119			

*Significant at .95
**Significant at .99

APPENDIX G (Continued)

TABLE XXXXIII

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-THREE INTERVAL MONSANTO EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	*F* values
Color	1	5.208	5.208	2.97
Brand	4	3.380	.845	4.82**
Treatment	1	.075	.075	.43
Judge	2	11.450	5.725	3.26*
CxB	4	1.667	.417	.24
TxB	4	.467	.117	.07
CxT	1	.075	.075	.04
CxJ	2	.617	.308	.18
TxJ	2	.350	.175	.10
BxJ	8	4.050	.506	.29
CxBxT	4	1.800	.450	
CxBxJ	8	4.383	.548	
BxTxJ	8	2.483	.310	
CxTxJ	2	4.450	.225	
Residual	68	15.050	.221	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX G (Continued)

TABLE XXXXIV

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-FOUR INTERVAL MONSANTO EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	F values
Color	1	9.075	9.075	6.06*
Brand	4	33.800	8.450	5.64**
Treatment	1	.075	.075	.50
Judge	2	46.350	23.175	15.46**
CxB	4	1.800	.450	.30
TxB	4	1.467	.367	.24
CxT	1	.408	.408	.27
CxJ	2	1.950	.975	.65
TxJ	2	1.350	.675	.45
BxJ	8	9.150	1.144	.76
CxBxT	4	1.133	.283	
CxBxJ	8	3.550	.444	
BxTxJ	8	3.483	.435	
CxTxJ	2	.017	.008	
Residual	68	22.317	.328	
Total	119			

*Significant at .95

**Significant at .99

APPENDIX G (Continued)

TABLE XXXXV

ANALYSIS OF VARIANCE ON DIFFERENCES BETWEEN

ZERO-FIVE INTERVAL MONSANTO EVALUATION

Source	Degrees of freedom	Sum of squares	Mean square	F values
Color	1	1.633	1.633	.94
Brand	4	35.200	8.800	5.05**
Treatment	1	.533	.533	.31
Judge	2	30.517	15.258	8.75**
CxB	4	.867	.217	.12
TxB	4	.800	.200	.12
CxT	1	.533	.533	.31
CxJ	2	1.017	.508	.29
TxJ	2	.717	.358	.20
BxJ	8	5.400	.675	.39
CxBxT	4	3.133	.783	
CxBxJ	8	4.233	.529	
BxTxJ	8	1.200	.150	
CxTxJ	2	.017	.008	
Residual	68	18.567	.273	
Total	119			

*Significant at .95
**Significant at .99

This Thesis was typed

by

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