THE EFFECT OF MACHINE WASHING AND DIFFERENT PROCEDURES IN DRYING AND IRONING ON THE APPEARANCE AND ON SELECTED PROPERTIES OF FOUR WASH-AND-WEAR FABRICS

By

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CHAPTER I

INTRODUCTION

The sale of wash-and-wear fabrics and garments made of these fabrics is promoted on the manufacturer's claim of ease of washing and drying, minimum ironing, and maximum crease retention and wrinkle recovery. The name "wash-and-wear" implies that a fabric or garment will maintain the ultimate in appearance after repeated launderings.

The ideal method for testing the washability of wash-and-wear fabrics is to duplicate the actual condition of use. However, for the purposes of this study, samples of the fabric were only laundered, although it is likely that soiling and wear would have an additional effect on the fabric properties.

The objectives of the investigation were to :

1) Make a subjective evaluation of the wash-and-wear fabrics after machine washing followed by tumble or line drying and different ironing treatments.
2) Determine the effects of machine washing and two drying treatments on selected properties of four wash-and-wear fabrics which differed in fiber content and finish.

Some manufacturers recommend totally unrealistic laundry procedures to be followed if maximum satisfaction is derived from the product. Labarthe (1) gives as an example of unrealistic washing conditions the following information found on a washing direction tag of a glazed bedspread, "This bedspread should be washed by hand in a stationary tub or in the bathtub, and hung up to drip dry."

Wham (2) states that "In laundry, unusual procedures involving complicated methods of handling have no place on a label."

According to statistics published in January, 1959, 90.0% of the wired homes in the United States in 1958 had washers and 15.6% of these homes had dryers. (3). With the advances that are being made with home laundry equipment, the consumer can not be expected to readily accept fabrics that must be washed by hand.

To meet the expectations of the consumer, the method of laundering used for the regular wash must also be adequate for the garments of wash-and-wear fabrics. To be truly satisfactory the garments should be capable of being washed in a regular load in the washing machine in water at a moderate or hot temperature with a regular household detergent, and dried in a household dryer or line dried without crease retention or loss of desired physical properties.

CHAPTER II

REVIEW OF LITERATURE

The term wash-and-wear has various meanings to the consumer depending on the experiences he has had with textile items labeled as such. Borghetty (4) states that "The term wash-wear was coined, promoted and sustantiated by the synthetic fiber producer who manufactured the first hydrophobic fibers that have intrinsic wrinkle resistance and wash-wear qualities."

The concept of wash-and-wear was well received by the public, but not all fabrics produced meet consumers' expectations. Richardson (5) explains, "When one thinks of wash-and-wear it is usual to visualize garments that are completely wrinkle free with sharp creases and no seam puckering."

Wham (2) states that "Wash-and-wear is a fabric which can be truly worn, washed and worn again with little or no ironing throughout its expected life." In addition, such garments must meet consumer expectancy for durability, colorfastness, shrinkage and other consumer demands.

Borghetty (6) defines wash-wear as "A garment that will drip dry without creases and require minimum care."

Nuessle (7) states that most people expect a wash-and-wear garment to have two characteristics:

1) On washing, the garment will dry relatively free of wrinkles, and so require little or no ironing; and
2) On wearing, the garment will resist mussing, and those wrinkles that do form will quickly hang out.

It is an accepted fact that the amount of care required for wash-and-wear varies. Reich (8) states that "The wash-wear qualities of a garment depend on several factors, such as the pattern and color of the fabric, the design of the garment, the use for which it is intended and the personal inclination of the wearer."

Stass (9) groups wash-and-wear fabrics into three categories.

1) Wash-and-wear: No ironing needed. Fabrics falling into this category will, in addition to the service requirements of their end use, be characterized by wearable appearance when washed and dried by standard methods without ironing.
2) Wash-and-wear: Slight touch-up needed. Fabrics falling into this category will, in addition to service requirements of their end use, be characterized by wearable appearance when washed and dried by standard methods followed only by a slight touch-up.
3) Easy Care: Needs only minimum ironing. Fabrics falling into this category should not be called wash-and-wear, but easy care, which implies that the dry fabric or garment will need dry ironing.

The two fundamental groups of fibers which can be wash-and-wear fabrics are the hydrophobic synthetic fibers which have inherent crease recovery and those fibers which lend themselves to chemical treatment which can impart these properties. The three basic methods of producing a wash-and-wear fabric are 1) the use of certain hydrophobic synthetic fibers, 2) the resin treatment of cotton or rayon and 3) the chemical modification of rayon or cotton. (10).

Yarn and fabric construction plays a vital role in the success of wash-and-wear garments regardless of the method used to produce the fabric. The best results are usually obtained when relatively short staple fibers are spun into soft, moderately twisted, singles yarns and woven into relatively open, medium count fabrics. The yarns and weaves which contain a minimum of internal strains and stresses give the best results provided they display sufficient tensile strength. (10).

The synthetics, polyester fibers and acrylics, exhibit a good dry crease recovery, and since they absorb extremely small amounts of water, they also have a good wet crease recovery. The polyester, Dacron is the most satisfactory fabric in crease recovery when made into wash-and-wear garments. Orlon, Acrilan and other acrylic fibers are also good, but nylon has not been rated so well in this use. Arnel, the triacetate, is also considered a satisfactory wash-and-wear fiber. Chemical finishes are not often used on fabrics made of Dacron, the acrylics or Arnel. (10).

Fabrics of synthetic fibers show permanent shrinkage control, minimum care and wrinkle recovery properties as well as high tensile strength. They wear well because of their good abrasion resistance. They have the undesirable characteristics of retaining static electricity due to the hydrophobic character of the fiber, and since they do not absorb perspiration, they are not as comfortable as the natural fibers. (10).

The success of cotton in the wash-and-wear industry has been due to the chemical modification of its hydrophobic character during the finishing processes. The ethylene urea resins, introduced by Foulds, Marsh and Wood of Tootal, Broadhurst and Lee Company, Ltd., England, are used with great success to change cotton into wash-and-wear. (10). Wash-and-wear on cotton is a crease resistant treatment durable to repeated washings. According to Borghetty (4) the degree of minimum care attained is a function of :

1) Type and selection of cotton fabric construction.

2) Type, durability, chlorine resistance, hand and effeciency of the synthetic thermosetting resin used to impart the effect.
3) End use requirement of the garment.

Nuessle (7) discusses the importance of type of fabric for crease-resistant treatment. A loose weave will respond to application of finish better than a tight weave in most cases. However, a 136/60 construction in broadcloth was weak after a wash-and-wear finish; a 136/72 was too tight a weave, but 136/64 was found to be a good compromise. He states:

> The construction is important, but the preparation of the fabric for finishing has a greater significance. It must be free of natural impurities, warp sizing and other extraneous materials. Improper fabric preparation will result in poor wash-and-wear properties, inadequate durability, and/or poor chlorine resistance.

Mercerization is regarded as having a good, although not pronounced effect on wash-and-wear qualities. Mercerization is usually done to increase luster, regardless of any effect on the wash-and-wear qualities.

The finishing agents used to impart a wash-and-wear quality to cotton fabrics are of two classes: nitrogenous and non-nitrogenous. The nitrogenous types include urea formaldehyde, melamine formaldehyde, ethyleneurea formaldehyde and triazone formaldehyde. Urea formaldehyde is not often used on cotton because of its poor resistance to chlorine and poor durability. Chlorine bleach will not ordinarily damage these fabrics if used in recommended concentration, but it does tend to remove the finish. The results depend on the formaldehyde to urea ratio used. Melamine formaldehyde is more durable than the urea type, but has a tendency to yellow when chlorine bleached. Ethyleneurea formaldehyde is similar to the urea type but offers lower chlorine retention and greater durability. Triazone formaldehyde retains little chlorine, and due to its greater buffering power, it does not result in fabric damage under severe laundry treatments. The two difficulties encountered by using triazone formaldehyde finish is the tendency to yellow regardless of whether or not bleach has been used, and the tendency to produce a fish odor. (7).

The non-nitrogenous type finish is formaldehyde which has been used as a major ingredient in a rayon stabilization finish, but it is not too successful for cotton due to the excessive strength loss and poor crease resistance. The Acetals and the Diepoxy type are two commercially available types of non-nitrogenous finishes which show the same deficiencies as the formaldehyde; but when used in conjunction with nitrogenous resins, they add greater durability and greater chlorine resistance. (7).

Resin finishes have a decided effect on the fabric properties, the most important being the enhanced crease recovery in both the wet and dry states. Other desirable effects are shrinkage control, quicker drying and resistance to rotting. There are also a number of undedirable effects caused by the finishing. Chief among these are reductions in tensile strength, tear strength and abrasion resistance. Two other problems resulting from treatment with nitrogenous resins are chlorine retention and a fish odor. In a report at the 37th National Convention of the American Association of Textile Colorists and Chemists, Reich (8) stated that "If an afterwash made alkaline with sodium carbonate or sodium perborate is used the fishy odor is not likely to develop in normal use."

One other problem of resin finishes is soil pick up, but Nuessle (7) claims this is usually the result of additives to the resin finish and not the resin itself. He states:

> Soil pickup if ofttimes as much a function of type of soil as of the type of finish. . . as the type of soil is varied, not only does the degree of soiling vary, but also there are marked reversals in soiling tendency.

Some of the disadvantages can be eliminated by blending the synthetic fibers with natural, but this must be done with care to obtain the best ratio of the two fibers used.

The method of chemical modification of cotton produces effects which are difficult to distinguish from those produced by the resin treatment method. Chemical modification consists of reacting the fabric with organic compounds which cross-link with the hydroxyl groups of the cellulose. The process tends to tie together pairs of cellulose molecules, adding rigidity to the molecular structure and causing the fabrics to resist or eliminate distortion. Fabrics finished by this method are more prone to mussiness during wear than resin treated fabrics. The wet crease recovery is higher than in the dry state, therefore, the wrinkles formed during the washing process will fall out during drying, but wrinkles formed during wearing are more permanent. This fact also causes the chemically modified fabric to be more satisfactory if line dried instead of tumble dried. (10).

Richardson (10) states that "The chemical modification also reduces the tensile and tearing strengths of the fabric, and the wet strengths are generally lower than those of the fabric in the dry state."

To protect wash-and-wear from shrinkage in laundering, latent shrinkage is built into the cloth by stabilizing it with resin after the fabric has been held to unnatural physical dimensions. The fabric remains dimensionally stable as long as the resin stabilization lasts. However, many of the resins used are removed with one or two commercial launderings in which acid sours are used. If this be the case, rapid shrinkage can and usually does take place. Also, some resins start to hydrolyze with the first washing and continue to do so with subsequent launderings, and by the sixth or seventh washing there is no resin left to stabilize the dimensions of the fabric. (10).

One of the most important characteristics of any fabric is the way in which it behaves in the laundering process. The Committee on Dimensional Changes in Textile Fabrics (11) stated "Washability' includes many important factors, primary among which are colorfastness, dimensional stability and durability of the finish."

Burlington Industries specify that fabrics made of synthetic fibers or synthetic fiber blended with any other fiber should be washed at 100° F. for maximum performance with respect to least wrinkling, best pressed-crease retention, adequate soil removal, least soil redeposition and least danger of dye bleeding. The amount of soap or detergent necessary is dependent on water-hardness, kind of soap or detergent used, and the soil present in the clothes. (9).

The desirable fabric property of wash-and-wear is the ability to recover from wrinkles resulting from wear and laundering. Wrinkling is caused by the incomplete recovery of the fibers and yarns within a fabric from bending which occurs during wear and laundering. Two types of wrinkles are produced by wear; one due to the body movements and the other due to compression by the weight of the body. Factors influencing the wrinkling of fabrics during wear are the temperature and moisture content of the fabric in contact with the body, the pressure, the time the fabric is deformed and the time for recovery, and the number of times the fabric is bent in the same location. (12).

Blue (13) found that wrinkles, creases, and surface deformations are all influenced by the ability or lack of ability of fibers, yarns and fabrics to deform, and that the factors which influence a fabrics' ability to be free from wrinkles are swelling, shrinkage, yarn size, twist, thread spacing, yarn packing, filament denier, weave, calendering and fabric structure.

It is a popular belief that laundering produces wrinkles, but in reality the machine agitation or the washing step of laundering removes wrinkles which were formed in wear. The so-called wash wrinkles are not present in garments which have been agitated and hung to drip dry. The formation of wrinkles during laundering occurs during the spinning operations and should be called spin wrinkles. (12).

According to Wilkinson and Hoffman (12) the use of warm water is undesirable during spinning due to the decrease in fabric temperature which takes place during spinning. The decrease in temperature causes the setting of wrinkles in fabrics made of thermoplastic fibers. The decrease in temperature does not affect hydrophilic fibers, but the decrease in water content causes a setting of the spin wrinkles. Fabrics which had been washed in a machine which included the usual cycles of wash agitation, rinse, spin, rinse agitation and spin dry, and dried by one of three methods, drip, line or tumble gave best results when tumble dried. Those fabrics which were removed before the final spin-dry operation rated second best.

Nuessle (7) also found that in most cases tumble drying gave the best results. This was particularly true in the case of rayon. Drip-drying of a soaking wet garment gave a somewhat poorer result. Worst of all for most finishes was the practice of spinning, as in the last spin cycle of washing, followed by line drying.

Wet and dry crease recovery are of major importance in determining wash-and-wear behavior. The relationship between the two depends on the method of drying used. For tumble drying, both wet and dry crease recovery must be increased to achieve good results from cotton and rayon. In line or drip drying, wet crease recovery is of more importance than dry. (14). Fabrics with dry crease recovery will tend to eliminate deformations after the drying has been completed.

In a study by Mack et al. (15) of the performance of wash-and-wear garments using three methods of washing, hand, home automatic and power, and allowing all garments to drip dry with the exception of those which were labeled by the manufacturer as being able to withstand machine drying, only a few garments were regarded as wearable without ironing, both as to the appearance of the fabric and the seams. Strength losses of the garments in the twenty-five washings in the study were negligible and shrinkages were low in many of the fabrics. The stitching of the garments was found to be one of the definite causes of poor wash-and-wear qualities. Factors which caused the poorer qualities were incompatibility of fabric and thread, sewing machine needles, and stitches per inch.

All phases of industry have proposed definitions of wash-and-wear, also test methods, evaluation techniques and standards. Most methods published have been similar in sample preparation, service requirement, laundry procedure and drying directions, but have not had a uniform method of subjective evaluation. (16).

A present method for subjective evaluation of wash-and-wear fabrics is to compare the sample of fabric that has been washed and dried under any of several standard conditions, and viewed under lighting conditions by a panel of raters with a set of photographic standards which show fabric swatches with varying degrees of wrinkling. The swatches are then assigned a number from one to five with five being the highest or designating the best appearance. This method is subject to large variations between individual ratings and judging panel ratings. Other difficulties found in the subjective evaluation method is the effect of a few large creases versus many small creases, the effect of color, pattern, fabric texture and luster. (16).

For an objective analysis of wrinkling, a device known as a Wrinklemeter is used. The Wrinklemeter determines the reflectance of the fabrics by photoelectric means. This instrument was made available for research by the Clothing and Housing Research Division, Institute of Home Economics, Agricultural Research Service, U. S. Department of Agriculture, and was built by Hunter Associates Laboratories, McLean, Virginia. The Clothing and Housing Research Division has found significant correlations between Wrinklemeter readings and visual judgment of wearable appearance. (17).

CHAPTER III

THE EXPERIMENT

A. Introduction

Four "wash-and-wear" white fabrics suitable for dresses and blouses were used in the investigation. The fabrics were laundered in an automatic washer and dried by two methods: line drying and by an automatic dryer. Samples were rated subjectively for freedom from wrinkles after no ironing, steam ironing and damp ironing. Fabric properties measured quantitatively were: crease recovery, stiffness, shrinkage, yarns per inch, light reflectance, breaking strength, elongation and thickness.

B. Selection and Preparation of Fabric Samples

The four fabrics used for the experiment were 1) blend of 45 per cent linen and 55 per cent rayon, 2) blend of 65 per cent Dacron and 35 per cent cotton, 3) all Dacron, and 4) all cotton which had a resin finish. These fabrics were chosen to give a variety of wash-and-wear fabrics for the experiment. The percentage of each fiber in the blends was known but the method of resin treatment was not known. The fabrics varied in size of yarn and in closeness of weave. The rayon and linen fabric was much coarser in texture than the other fabrics. The yardage of each fabric was taken from a single bolt of fabric to obtain as much uniformity as possible among samples.

The samples were cut 12 inches by 12 inches and randomly numbered.

They were hemmed with different colored thread to identify the ones to receive each drying treatment and to readily identify one fabric from another. Because the fabrics dried at a different rate it was necessary to remove samples at different intervals from the dryer. The colored stitching helped to make a rapid and positive identification.

Thirty samples of each fabric were used in the experiment. Six were used for measurements before laundering and 12 were laundered and dried by each of the two drying procedures. Three of the 12 samples were used for measurement of crease recovery and stiffness at each laundry interval of 6, 12, and 18. Three samples were used for measurement of breaking strength and elongation after 18 launderings.

C. Laundry Procedure

The wash-and-wear samples were combined with enough dummy pieces of cotton fabric to make a six pound wash load. When samples were removed for testing after 6 and 12 launderings, additional dummy pieces were added to keep the wash load constant.

The washer was an agitator type with the four regular wash, spin rinse, deep rinse, and spin cycles. The machine was pre-heated and allowed to fill with water at 140° F. Three-fourths cup of dissolved low-sudsing detergent was added to the water before the washer load was added. Cold water was used during the rinsing cycle. The water temperature selection was made on the writer's belief that 140° F. is an average temperature normally used in household laundry. Bleaches, water softeners or other additives were not used in this experiment.

After the final spin, the fabrics were immediately removed from the washer and sorted according to the method of drying to be used. The dummy pieces were included in the load for the tumble dryer. The dryer was set at a medium to low temperature as recommended by the manufacturer for drying synthetic fabrics, and allowed to pre-heat. The test samples were removed as they dried, and were not allowed to become over-dry. The Dacron was removed after two minutes; the cotton-Dacron blend at four minutes; and the resin treated cotton and the rayon-linen blend at 10 minutes. As the fabrics were removed they were smoothed out flat by hand on a table to prevent wrinkling in handling.

The fabrics to be line dried were smoothed by hand on a flat surface as they were removed from the washer to prevent further wrinkling and hung in the warp direction on an indoor line. The laundering procedure was repeated through 18 washings and dryings.

Three samples of each fabric dried by the two methods were used for subjective evaluation. The preparation of the samples was 1) no further treatment after removing from line or dryer, 2) steam pressing and 3) regular ironing (dampened and ironed). The samples were rotated for the ironing treatment at the three laundry intervals so that the same samples did not receive the same treatment each time.

D. Test Procedures

For the subjective evaluation, the 24 treated samples were framed in black and placed at random on a light table surface in a well lighted room. Five graduate students in the Clothing, Textiles and Merchandising Department, Oklahoma State University rated the samples good, fair or poor as to acceptability using minimum wrinkling as a criteria for the standard. The composite score of the number of ratings was used in evaluating the results.

Recommended procedures of the American Society for Testing Materials were used for all the tests. (18). Laboratory conditions were

70-74° F. temperature and 65% relative humidity.

Crease recovery was measured on five specimens, warp and filling at 0 laundering and for each of the two drying procedures at 6, 12 and 18 launderings. The vertical strip method with the Monsanto tester was used, and the result recorded in degrees.

Stiffness of the fabrics was measured by the Cantilever test in which a 1" X 6" strip of fabric is projected along a horizontal plane and the bend of the fabric under its own weight is measured. Four specimen, warp and filling, were tested each time.

Yarns per inch were counted with a yarn counter at each laundry interval. The count was made on the same samples as were used for measurement of shrinkage and reflectance.

For measurement of shrinkage, three samples for each drying condition were marked with indelible ink at points giving a 10" square. The laundered samples were dampened and flat pressed at 6, 12, and 18 launderings and conditioned before they were measured. The same samples were measured, and the results reported as per cent shrinkage.

A Gardner Multi-Purpose Reflectometer was used to measure reflectance. This apparatus measures the amount of light reflected from the surface being tested through the use of a photoelectric cell and three colored filters, green, blue and amber. Values increase from zero for magnesium oxide to positive numbers for yellowish surfaces and negative values for bluish surfaces. In this study, reflectance is expressed as degree of yellowness. Three measurements were made on each sample.

The ravel strip method was used to determine breaking strength on the Scott Tester. Three specimens, warp and filling, were taken from each of the 12 samples. Because it was thought strength would be little affected by less than 18 launderings, strength was measured only at 0 and 18 launderings. The curve for elongation was obtained when breaking strength was determined.

The thickness measurements were taken in three places on each sample using a Compressometer. The readings were in 1/000 inch using 0.35 pounds pressure.

CHAPTER IV

DISCUSSION OF RESULTS

Subjective Evaluation

As indicated in Tables I and II, the ratings for the steam pressed and ironed cotton fabric were lower than the ratings for the other fabrics after these treatments. This fabric received more diversity in rating than any of the other fabrics and the line dried fabric rated higher than the machine dried.

TABLE I

SUBJECTIVE EVALUATION OF FOUR MACHINE DRIED FABRICS AT 0, 6, 12 AND 18 LAUNDERINGS BY FIVE PERSONS RATING FABRICS GOOD (G) FAIR (F) POOR (P)

	Method	Rating at Laundry Intervals												Composite		
Fabric	of	0			6			12			18			Score*		
	Ironing	G	F	P	G	F	P	G	F	P	G	F	P	G	F	P
Rayon & Linen	No Iron	5	0	0	3	2	0	1	2	2	3	2	0	12	6	2
	Steam	5	0	0	4	1	0	5	0	0	3	2	0	17	3	0
	Iron	5	0	0	4	1	0	4	1	0	5	0	0	18	2	0
Dacron & Cotton	No Iron	5	0	0	0	1	4	0	2	3	0	1	4	5	4	11
	Steam	5	0	0	3	2	0	3	1	1	4	1	0	15	4	1
	Iron	5	0	0	5	0	0	5	0	0	4	1	0	19	1	0
Dacron	No Iron	5	0	0	0	0	5	0	2	3	0	0	5	5	2	13
	Steam	5	0	0	5	0	0	2	3	0	2	3	0	14	6	0
	Iron	5	0	0	4	1	0	5	0	0	3	2	0	17	3	0
Cotton	No Iron	5	0	0	0	3	2	1	4	0	0	1	4	6	8	6
	Steam	5	0	0	1	4	0	0	4	1	1	4	0	7	12	1
	Iron	5	0	0	4	1	0	0	3	2	1	4	0	10	8	2

*Composite score: The total number of times rated good, fair and poor.

TABLE II

SUBJECTIVE EVALUATION OF FOUR LINE DRIED FABRICS AT 0, 6, 12 AND 18 LAUNDERINGS BY FIVE PERSONS RATING FABRICS GOOD (G) FAIR (F) POOR (P)

Fabric	Method of Ironing	Rating at Laundry Intervals												Composite Score*		
		0			6			12			18					
		G	F	P	G	F	P	G	F	P	G	F	P	G	F	P
Rayon & Linen	No Iron	5	0	0	0	0	5	0	1	4	0	0	5	5	1	14
	Steam	5	0	0	5	0	0	5	0	0	5	0	0	20	0	0
	Iron	5	0	0	5	0	0	5	0	0	5	0	0	20	0	0
Dacron & Cotton	No Iron	5	0	0	0	2	3	0	1	4	0	1	4	5	4	11
	Steam	5	0	0	3	2	0	4	1	0	4	1	0	16	4	0
	Iron	5	0	0	5	0	0	3	2	0	5	0	0	18	2	0
Dacron	No Iron	5	0	0	0	0	5	0	0	5	0	0	5	5	0	15
	Steam	5	0	0	2	3	0	2	3	0	1	3	1	10	9	1
	Iron	5	0	0	4	1	0	3	2	0	3	2	0	15	5	0
Cotton	No Iron	5	0	0	0	0	5	1	3	1	0	0	5	6	3	11
	Steam	5	0	0	1	1	3	2	2	1	0	5	0	8	8	4
	Iron	5	0	0	1	3	1	0	1	4	2	3	0	8	7	5

*Composite score: The total number of times rated good, fair and poor.

The machine dried rayon and linen fabric was favored over the line dried fabric when no treatment was given; however, the line dried fabric was rated good by the judges at all laundry intervals.

The method of drying had little effect on the ratings of the Dacron and cotton blend and the all Dacron fabric although the line dried fabrics rated slightly higher in the untreated state. The results of the ratings imply that freedom from wrinkles is a desired attribute of fabrics, and that some degree of ironing is necessary to make the fabrics acceptable.

Crease Recovery

As indicated in Table III, the degree of crease recovery for the rayon and linen and all cotton fabrics decreased slightly with laundering.

The method of drying appeared to have little or no effect on the results.

Crease recovery in the Dacron and cotton fabric varied at the laundry intervals but was about the same for the machine dried as the original fabric after 18 launderings. The line dried fabric was somewhat better in crease recovery than the machine dried fabric. The Dacron fabric improved in crease recovery with laundering. The method of drying had little or no effect on crease recovery of this fabric.

From these results it appears that the Dacron had a higher degree of crease recovery after laundering than the cellulosic fibers. The Dacron and cotton fabric was better in crease recovery than the rayon and linen. The laundered resin treated cotton was lowest in crease recovery.

TABLE III

CREASE RECOVERY OF THE FOUR FABRICS AT 0, 6, 12, AND 18 WASHINGS WITH TWO METHODS OF DRYING*

Fabric	Method of Drying	Crease Recovery in Degrees at Laundry Intervals							
		0		6		12		18	
		Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Rayon & Linen	Dryer	124	122	113	118	110	120	108	113
	Line	124	122	120	123	115	119	116	119
Dacron & Cotton	Dryer	126	124	129	120	133	129	127	124
	Line	126	124	135	131	134	130	134	128
Dacron	Dryer	118	118	145	138	146	143	141	138
	Line	118	118	144	139	149	141	143	140
Cotton	Dryer	100	101	91	93	95	98	93	96
	Line	100	101	97	99	92	96	94	95

*Average of measurements from three samples.

Stiffness

Laundering had significant effects on the stiffness of Dacron as indicated in Table IV. The average length of overhang at 18 launderings was considerable less for this fabric in both warp and filling than for the other fabrics tested in comparison to the measurements at 0 laundering.

The loss of stiffness of all other fabrics appeared to be so small as to not be of any importance. Also, there appeared to be little difference in stiffness between the dryer dried and line dried fabrics.

TABLE IV

STIFFNESS OF THE FOUR FABRICS AT 0, 6, 12 AND 18 WASHINGS
WITH TWO METHODS OF DRYING*

Fabric	Method of Drying	Overhang in cm. at Laundry Intervals							
		0		6		12		18	
		Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Rayon & Linen	Dryer	4.93	4.16	4.71	3.95	4.81	4.01	4.57	3.98
	Line	4.93	4.16	4.70	4.03	4.80	3.98	4.75	3.99
Dacron & Cotton	Dryer	4.32	2.99	3.92	3.09	3.90	2.77	3.99	2.84
	Line	4.32	2.99	4.00	2.80	4.04	2.80	4.07	2.86
Dacron	Dryer	4.60	4.95	2.84	3.76	2.99	3.65	2.70	3.66
	Line	4.60	4.95	2.78	3.64	2.91	3.60	2.73	3.70
Cotton	Dryer	4.07	3.15	4.04	3.13	4.07	3.21	4.24	3.35
	Line	4.07	3.15	4.03	3.16	4.09	3.19	4.26	3.39

*Average of measurements from three samples.

Shrinkage and Yarns Per Inch

As indicated in Table V, none of the fabrics shrank as much as 3 per cent. Shrinkage was highest in the warp direction for the rayon and linen and the Dacron fabrics. The machine dried Dacron fabric appeared to have a greater shrinkage in the warp direction than the other fabrics; however the line dried samples exhibited very little shrinkage. The excess shrinkage may be due to the method of drying. The shrinkage of the rayon and linen fabric was found to level off at 12 launderings for both warp and filling. The amount of warp shrinkage for both methods of drying was fairly high. The per cent of shrinkage increased with each laundering in the case of the Dacron and cotton blend although the method of drying apparently had little or no effect on the shrinkage. The cotton fabric responded in much the same manner as the Dacron and cotton.

TABLE V

SHRINKAGE OF THE FOUR FABRICS AT 0, 6, 12, AND 18 WASHINGS WITH TWO METHODS OF DRYING*

Fabric	Method of Drying	Shrinkage in % at Laundry Intervals							
		0		6		12		18	
		Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Rayon & Linen	Dryer	--	--	1.98	.60	2.43	1.20	2.43	1.20
	Line	--	--	1.73	1.03	2.20	.92	2.30	.58
Dacron & Cotton	Dryer	--	--	.59	.23	.92	.10	1.02	.47
	Line	--	--	.69	.23	.81	.46	1.03	.47
Dacron	Dryer	--	--	2.08	.81	2.43	1.20	2.89	1.03
	Line	--	--	.51	.69	.86	1.20	2.04	.17
Cotton	Dryer	--	--	.17	.47	.69	.92	1.97	.81
	Line	--	--	.17	.47	.28	.10	1.86	.47

*Average of measurements from three samples.

The number of yarns per inch (Table VI) remained unchanged with few exceptions which further indicates that the fabrics might be considered dimensionally stable.

Reflectance

At 0 laundering, the rayon and linen fabric was more yellow than the other fabrics. (Table VII). With repeated launderings this fabric tended to become less yellow.

TABLE VI

YARN COUNT AT 0, 6, 12 AND 18 WASHINGS WITH TWO METHODS OF DRYING*

Fabric	Method of Drying	Yarns Per Inch at Laundry Intervals							
		0		6		12		18	
		Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
Rayon &	Dryer	41	37	42	37	42	37	42	37
Linen	Line	41	37	41	37	41	37	42	37
Dacron &	Dryer	119	74	120	75	120	76	120	76
Cotton	Line	119	74	121	75	121	75	120	76
Dacron	Dryer	106	66	105	67	104	67	105	67
	Line	106	66	104	67	104	67	105	67
Cotton	Dryer	143	60	144	61	145	62	146	61
	Line	143	60	144	61	145	61	145	61

*Average of measurements from three samples.

The increase in yellowness occurred within the first six launderings in the Dacron and cotton fabric. After this initial increase, the degree of yellowing leveled off and remained constant throughout the 18 launderings. The line dried fabrics evidenced a slower increase in yellowing than did the machine dried fabrics, but the difference was very slight.

The Dacron remained about the same throughout the 18 launderings although the line dried samples became slightly less yellow than the machine dried fabrics.

The cotton fabric appeared to be nearer the magnesium oxide stand- at 0 laundering than did the other fabrics, but increased in yellowness with repeated launderings. The method of drying indicated that the line dried fabric was more consistant in remaining less yellow than the machine dried fabric.

TABLE VII

REFLECTANCE, EXPRESSED AS YELLOWNESS, OF THE FOUR FABRICS AT 0, 6, 12 AND 18 WASHINGS WITH TWO METHODS OF DRYING*

Fabric	Method of Drying	Yellowness at Laundry Intervals Std. = 0			
		0	6	12	18
Rayon & Linen	Dryer	5.0	5.0	4.5	4.4
	Line	5.0	4.9	4.7	3.8
Dacron & Cotton	Dryer	1.9	3.0	2.9	2.9
	Line	1.8	2.9	2.8	2.8
Dacron	Dryer	2.2	2.3	2.3	2.1
	Line	2.1	2.0	1.7	1.9
Cotton	Dryer	1.4	1.8	2.3	2.1
	Line	1.3	1.8	1.8	1.8

* Average of measurements of three samples.

In all cases, those fabrics which were line dried remained less yellow than those dried in the automatic dryer. The fabrics of whole or partial cotton content were less yellow at the initial testing than the synthetic fabric, but evidenced more yellowness with laundering; whereas, the Dacron remained about the same and the rayon and linen became less yellow.

Breaking Strength

The breaking strength of the four fabrics at 0 and 18 launderings is given in Tables VIII and IX. Although no serious losses occurred, the line dried fabrics appeared to be less affected than the machine dried fabrics with the exception of the rayon and linen fabric, in which case the line dried fabrics lost in strength more than those dried in the dryer.

In the initial breaking strength test of the rayon and linen fabric, the breaking strength was higher in both warp and filling than for the other fabrics tested, but the Dacron and cotton was also high in the warp.

The cotton and the Dacron and cotton fabrics lost strength in the warp but gained strength in the filling. The gain of filling strength in the Dacron and cotton may be due to the cotton content of the fabric since the all cotton fabric evidenced considerable gain in the filling and the Dacron fabric had no gain. The amount of loss in the warp for the cotton and Dacron fabric was 6.0 pounds in the machine dried samples and 1.4 pounds in the line dried. The cotton fabric lost 4.5 pounds in the warp for the machine dried method and only 2.5 pounds for the line dried method. The amount of gain for the filling was 2.9 pounds for the machine dried samples and 4.7 pounds for the line dried method. The line dried samples of both fabrics were stronger than the machine dried samples.

TABLE VIII

BREAKING STRENGTH, ELONGATION AND THICKNESS OF THE FOUR FABRICS BEFORE LAUNDERING*

	0 Laundering				
Fabric	Breaking Strength in lbs.		Elongation in %		Thickness in inches
	Warp	Filling	Warp	Filling	
Linen & Rayon	75.9	68.1	9.17	16.34	.0186
Dacron & Cotton	70.5	25.7	34.86	26.11	.0070
Dacron	42.1	35.5	33.05	12.15	.0052
Cotton	53.6	29.7	6.74	10.42	.0088

*Average of measurements of four samples.

Elongation

The per cent of elongation in both warp and filling at 0 and 18 launderings was highest for the Dacron and cotton blend, and change due to washing and the two methods of drying was slight. (Tables VIII and IX.

TABLE IX

BREAKING STRENGTH, ELONGATION AND THICKNESS OF THE FOUR FABRICS AFTER 18 WASHINGS AND TWO METHODS OF DRYING*

		18 Launderings				
Fabric	Method of Drying	Breaking Strength in lbs.		Elongation in %		Thickness in inches
		Warp	Filling	Warp	Filling	
Rayon & Linen	Dryer	72.3	64.6	7.57	12.64	.0200
	Line	70.4	58.7	7.08	11.95	.0199
Dacron & Cotton	Dryer	64.5	26.0	33.96	25.55	.0080
	Line	69.1	25.8	34.03	24.72	.0080
Dacron	Dryer	34.1	31.5	30.62	10.00	.0072
	Line	38.0	34.9	30.35	11.46	.0072
Cotton	Dryer	49.5	32.6	7.29	7.29	.0109
	Line	51.1	35.4	7.64	7.92	.0098

*Average of measurements of four samples.

The cotton fabric had the lowest elongation but there was a slight increase in the warp elongation after laundering. The filling elongation decreased. The method of drying apparently made little difference in either case.

The change in elongation in the rayon and linen blend and the Dacron was also slight, and as in the other fabrics, there appeared to be no correlation between the results and the method of drying.

Thickness

The linen and rayon fabric was much thicker than the other fabrics. The increase in thickness of the four fabrics due to laundering was small. (Tables VIII and IX). It is doubtful that the increase would in any way affect the suitability of the fabric in its use as most fabrics tend to increase in thickness after laundering to relieve the compression of the calendering process. Cotton was the only fabric in which the method of drying appeared to make even a slight difference in the results.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The effects of washing and two methods of drying, automatic dryer and indoor line, on selected properties of four white "wash-and-wear" fabrics was determined by tests performed at several intervals of laundering. The fabrics were also rated subjectively to determine acceptance after several ironing treatments.

The fabrics used were a 55% rayon and 45% linen blend, a 65% Dacron and 35% cotton blend, an all Dacron and an all cotton with a resin finish. The four lengths of fabric were cut into samples, randomly numbered and divided into two lots for the methods of drying.

All samples were washed together in an agitator type machine using water at 140° F. and a low sudsing synthetic detergent. The fabrics were dried according to the assigned method.

Tests for breaking strength, elongation and thickness were made at 0 and 18 launderings. Tests for subjective evaluation, crease recovery, stiffness, shrinkage, yarns per inch and reflectance were made at 0, 6, 12 and 18 launderings. At each test interval, samples to be measured for crease recovery and stiffness were removed from the wash load. The fabric samples used for subjective evaluation were rated and measured for shrinkage, yarns per inch and reflectance and returned to the wash load; and after 18 launderings, these samples were used for measuring breaking strength and elongation.

1. In the subjective evaluation, the method of drying had little effect on the rating of the unironed Dacron and cotton blend and the all Dacron fabrics. The machine dried rayon and linen and resin treated cotton rated somewhat higher than the line dried samples of the same fabric. The ironed samples rated highest for the three ironing treatments, and rating for untreated fabrics were low in most cases.

2. The degree of crease recovery of the rayon and linen, the Dacron and cotton, and cotton fabrics was not affected by the method of drying. The line dried Dacron was somewhat higher in crease recovery than the machine dried fabric. Crease recovery was lowest for the resin treated cotton fabric and highest for the all Dacron.

3. There was little change in stiffness due to laundering of the rayon and linen, the Dacron and cotton and cotton fabrics with either drying method. The stiffness in both warp and filling of Dacron decreased with laundering.

4. None of the fabrics had shrinkage in the filling great enough to be of practical importance concerning the use of the fabrics. Warp shrinkage at 18 launderings was over 2.5% for only one fabric, the Dacron. The yarn count remained almost the same throughout the experiment.

5. The rayon and linen fabric became less yellow, the Dacron stayed about the same, and the Dacron and cotton and the cotton fabric increased in yellowness. The line dried fabrics remained less yellow than those fabrics dried by machine.

6. No serious losses in breaking strength occurred during the laundry processes. A small gain in strength was found in the filling of the machine dried Dacron and cotton and in the filling of the cotton

fabric dried by both methods. The line dried fabrics were stronger than the machine dried fabrics except for the rayon and linen fabric.

7. The change in elongation was very slight, and the method of drying had little effect, although the line dried fabrics were generally somewhat higher in elongation than those machine dried.

8. The increase in thickness of the four fabrics was no more than would be expected of new fabrics after laundering.

Recommendations

The author suggests several further studies of the wash-and-wear fabrics.

1. The results of this investigation give information only about the effects of laundering on the four fabrics. To determine the serviceability of the fabrics it would be necessary to subject garments made of the fabrics to actual wearing conditions.

2. Subjective evaluation might be used more extensively and with greater reliability if photographic standards showing different degrees of wrinkling were used. Also, subjective evaluation might be improved if members of a judging panel rated the same fabrics more than one time.

3. The washing might be done with the addition of such laundry aids as water softeners and bleaches and the effects compared with those found in this study.

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