THE RESTORING OF DARK COTTONS TO THE ORIGINAL
STIFFNESS AFTER LAUNDRING

by

Emma Lusetta Gough

Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of
MASTER OF SCIENCE
in
Clothes and Textiles
Home Economics Department

APPROVED:

Director of Graduate School

Dean of Agriculture

APPROVED:

Head of Department

Major Professor

June, 1955

Blacksburg, Virginia
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Review of Literature and Justification of Study</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Procedure</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Part I, Testing Suitability of Three Types of Stiffening Agents</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Judging</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Experiment II, Starch Accessories</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Addition of Accessories</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Stiffening of Samples</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Experiment III, Commercial Stiffening Agents</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Experiment IV, Permanent Finishes</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Validity of Judging</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Meter Readings</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Limitation of the Study</td>
<td>14</td>
</tr>
<tr>
<td>II</td>
<td>Suitability of Available Stiffening Agents for Dark Cottons</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>25</td>
</tr>
<tr>
<td>III</td>
<td>Adaptation of Powdered Starch for Dark Cotton in Home Laundering</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Hard Water and Distilled Water</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>32</td>
</tr>
<tr>
<td>IV</td>
<td>Adaptation of Commercial Stiffening Agents for Dark Cottons in Home Laundering</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>39</td>
</tr>
<tr>
<td>Chapter</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>V</td>
<td>Effects of Home Laundering on Permanent Finish Cottons</td>
<td>40</td>
</tr>
<tr>
<td>VI</td>
<td>Summary and Conclusions</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Recommendations</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Acknowledgments</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Bibliography</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>Vita</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Appendix</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Score Cards</td>
<td>i</td>
</tr>
<tr>
<td></td>
<td>Explanation of $x^2$</td>
<td>11</td>
</tr>
</tbody>
</table>
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comparison of Stiffened Material with Original for Three Stiffening Agents</td>
<td>19</td>
</tr>
<tr>
<td>2.</td>
<td>Comparison of Stiffened Material with Original for Three Stiffening Agents</td>
<td>20</td>
</tr>
<tr>
<td>3.</td>
<td>Comparison of Stiffened Material with Original for Three Stiffening Agents</td>
<td>20</td>
</tr>
<tr>
<td>4.</td>
<td>Comparison of the Effectiveness of Plastic Starch and Powdered Starch Plus Borax</td>
<td>28</td>
</tr>
<tr>
<td>5.</td>
<td>Comparison of the Effectiveness of Plastic Starch and Powdered Starch Plus Glycerine</td>
<td>28</td>
</tr>
<tr>
<td>6.</td>
<td>Comparison of Powdered Starch with Borax in Distilled and Tap Water Solutions</td>
<td>29</td>
</tr>
<tr>
<td>7.</td>
<td>Comparison of Powdered Starch with Glycerine in Distilled and Tap Water Solutions</td>
<td>29</td>
</tr>
<tr>
<td>8.</td>
<td>Comparison of Stiffened Material with Original Sample for Three Commercial Stiffening Agents</td>
<td>36</td>
</tr>
<tr>
<td>9.</td>
<td>Comparison of Stiffened Material with Original Sample for Three Commercial Stiffening Agents</td>
<td>36</td>
</tr>
<tr>
<td>10.</td>
<td>Comparison of Stiffened Material with Original Sample for Three Commercial Stiffening Agents</td>
<td>37</td>
</tr>
<tr>
<td>11.</td>
<td>Comparison of the Permanent Finish of Three Cottons After Fifty Washings as Compared to the Original</td>
<td>42</td>
</tr>
</tbody>
</table>
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Restoring Dark Cotton to Original Stiffness</td>
<td>21</td>
</tr>
<tr>
<td>2.</td>
<td>Powdered Starch with Accessories</td>
<td>39</td>
</tr>
<tr>
<td>3.</td>
<td>Starch Solution Plus Borax Made with Distilled and Tap Water</td>
<td>31</td>
</tr>
<tr>
<td>4.</td>
<td>Commercial Stiffening Agents</td>
<td>38</td>
</tr>
<tr>
<td>5.</td>
<td>Retention of Permanent Finish Under Home Laundering Conditions</td>
<td>43</td>
</tr>
<tr>
<td>6.</td>
<td>Retention of Permanent Finish Under Home Laundering Conditions</td>
<td>44</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

Review of Literature and Justification of Study

This study has resulted from the need expressed by homemakers for a suitable method of restoring dark cottons to their original appearance after home laundering. Dark cottons for apparel purposes are relatively new in the clothing industry. The type of stiffening agents used on light cottons leaves the dark cottons with a white appearance after ironing. The published literature devotes little space to the problem.

Interest in stiffening agents for cottons dates back to the sixteenth century. "Queen Elizabeth with her ruffs caused a certain Dutch woman to invent the art of starching," says Balderston (2). The agents used in home laundering for stiffening always have been some form of starch. In addition to restoring stiffness, starch is believed to keep washable garments clean for a longer time by covering and holding down the surface fibers that catch the dust. The dirt is deposited on the starch film and washes out with the starch when the garment is laundered. Proper starching gives each washable garment the desired degree of crispness and/or pliability. It can keep fabrics looking smooth and unrumpled for a considerable period of time. Also, it can make the beauty of design and color stand out in the fabric. The proper amount of stiffness makes them easy to iron because starched articles hold their shape (6).
Stiffening agents are on the market in several forms. The lump and powdered laundry starches usually contain raw starch and/or modified starch: they are sold under such brand names as "Argo", "Bright Sale", "Linit", Niagara", quick Elastic", Stailey's", etc. Raw starch and many modified starch products require boiling water to make starching solutions. Some modified starches contain wax, blueing and perfume. They are available under such names as "Bright Sale", "Easy Monday", "King", "Linit", "Quick Elastic", "Sta-Flo", Vano", Zippy". Other liquid finishes, the so-called "plastic starches", found in many retail stores, are not starches at all but water emulsions of clear plastic materials. Some are soluble finishes: for example, "Glasstex", "Nocco" and "Size-A-Kleen". Others are semi-permanent plastic finishes such as "Korex", "Perma-Starch", "Texize". Both types come in ready-to-use concentrated solution with specific directions on the bottle for diluting and applying them to fabrics. (6), (8), (9), (10).

Several studies have been made on the effectiveness of different types of stiffening agents on the wearing quality of fabrics and their characteristics. (4), (9), (3).

Harper found in her study of starches that plastic starch did not cause a significant increase in the breaking strength of the three fabrics over other starches, although it did seem to give slightly more protection than did the other three starches. Plastic starch increased the abrasion or wear resistance of all the test samples over both control and original fabrics. The solid and plastic starches gave greater resistance to abrasion than did the other two starches. The plastic starch
gave stiffer fabrics in all cases than did any of the other starches. (4).

Bennett and Ginter's (3) study points out that a high degree of crispness seemed to be typical for the fabrics that were finished with a plastic starch. The wax type starch produced a less crisp fabric than did the plastic type. This starch seemed to resist some stains and was more receptive to others.

As stated in the Consumer's Report of June 1949, powdered starch increases the abrasion resistance, but one plastic starch doubled the resistance of some fabrics. An increase in the abrasion resistance adds significantly to the wearing life of clothes. Plastic starch did not work as well on light weight fabrics, such as voiles, as it did on heavier fabrics. (9).

Consumer's Report of May 1950 states, "... plastic starch stiffens cotton fabrics evenly without spotting or staining them. Manufacturers recommend applying starch to dry clothes and ironing dampened clothes with ironing temperature slightly lower than ordinary temperature for cottons. (10).

Consumer's Research Bulletin of June 1952 pointed out that the stiffness was lost much more quickly from starched fabrics (including those starched with powdered starch) dried in an automatic dryer than from pieces of the same fabric that had been hung up to dry. After one drying in the automatic dryer, the starched fabrics almost completely lost their stiffness, while those hung up to dry retained their stiffness through eight to ten washings. One plastic starch was used satisfactorily on black broadcloth. (3).
"Life" magazine reports that plastic starch penetrates among the individual thread fiber, melts when it comes in contact with the heat of the iron, thus grasping the fibers and keeping them from being torn away by laundering or wear. Fabrics stiffened with a plastic starch will retain their crispness for as many as ten launderings. (11).

McLaughlin (7) stresses that proper starching can give each washable fabric the desired degree of crispness and/or pliability. It keeps fabrics looking smooth and unrumpled for a considerable period of time and also makes them easier to launder.

Anderson says dark cottons are difficult to launder since starch tends to show up white after ironing. This may be eliminated by adding accessories to starch. (1).

Kendell points out that starch has come in new forms, new ingredients have been added, and directions have been simplified. (5).

Seydel says, "The exact procedures for many of the specialty starches are generally well-guarded manufacturing secrets." Manufacturers used many binders for sizing, among which are gum arabic, gum tragacanth, paraffin, wax, borax, glycerin, etc. (12).

In most of these studies, various kinds of raw starch, modified starches and a few special finishes with gelatin, gum arabic and blueing have been used. Also some research has been done on plastic starch. These studies conclude that the plastic type of starch gives a higher degree of crispness than the vegetable starch. Also, that powdered, lump or cubed starches tend to give a higher degree of crispness
to fabrics than do comparable concentrations of crystalline starches. Precooked starch gives a finish similar to crystalline hot water starch. (6). One problem connected with certain plastic starches is that commercial tricresyl phosphate, used as a plasticizer in such starch substitutes, exists in several forms. Of these, one (ortho isomer) is a very toxic cumulative poison. It is believed that the commercial plastic starches may be free of this isomer, or it will be present in quantities so small as not to imply serious harm to the user. Most plastic starches emit unpleasant odors during application but these disappear after drying and ironing. (8).

In an effort to increase the competitive status of dark cottons with wool and certain man-made fibers such as nylon, orlon, dacron, etc., manufacturers are attempting to give cottons a permanent stiffness during finishing similar to that of the man-made fibers which resulted from the weaving process. Only a few manufacturing concerns are giving a permanent finish to dark cottons, and there appears to be no definite research as to how permanent these finishes are under home laundering conditions. It appears that nothing has been done to adapt these commercial methods of finishing to home use.

Since cotton is a very important agricultural product in the South, and the extent to which cotton can compete with wool and the man-made fibers for use in the apparel industry depends largely upon its washability, research on ways of restoring dark cottons to their original appearance after laundering is urgently needed.
PROCEDURE

The study was divided into four experiments: Experiment I, Suitability of three types of stiffening agents, Experiment II, Starch accessories, Experiment III, Commercial stiffening agents, and Experiment IV, Permanent finishes.

Four cotton fabrics, namely, dark green wrinkled cotton, a dark green Indian head, a medium weight solid navy blue permanent finish cotton, and a medium weight navy blue printed permanent finish cotton were used in this study.

In preparation for the experimental work the materials were divided into fifteen inch squares. Samples of materials which had a tendency to ravel were hemmed before the experimental work was begun. All of the samples were coded with indelible cloth marking ink.

Photovolt reflection meter readings were taken on each test sample, starting at the upper left hand corner, reading left to right. Four readings were recorded for each sample.

All samples to be used in the study were washed twice in a laundromat automatic electric washing machine before the experimental work on stiffening agents was begun.

Each wash of dry clothes was weighted on the washing machine scales which indicated small load, therefore the water saver was set on "small" for all washings. The dial was set at medium temperature (110°F - 112°F) for each wash and the normal wash cycle was used. This cycle required a total of forty minutes which included washing, rinsing, and spin drying. One-fourth cup of all purpose detergent
recommended for automatic washers was used for each wash.

The washed samples were sorted in groups of three. Those to be stiffened by the powdered and liquid starches were left damp as they came from the washer; those to which the synthetic starch was to be added were dried on a clothes rack.

**Part I. Testing Suitability of Three Types of Stiffening Agent**

The three agents used in this study were powdered starch, synthetic liquid starch, and non-synthetic liquid starch. They were prepared according to the manufacturer's directions. The processes used were as follows: 1. Powdered starch: Four tablespoons of starch were placed in a four-quart container. One-half cup of cold water was poured over the starch and the solution was stirred until creamy. To this solution was added two quarts of boiling water. The solution was stirred continuously with a wooden spoon until it gave a clear appearance. The starch solution was covered and permitted to stand until it reached room temperature. Before using, it was strained through a cloth bag.

2. Liquid starch: Two cups of concentrated liquid starch were placed in a four-quart container. To this was added gradually, six cups of luke warm tap water. This solution was stirred continuously with a wooden spoon until well mixed.

3. Plastic starch: Into a container with two and one-fourth fluid ounces of plastic starch, two quarts of luke warm water were gradually added.
In the stiffening procedure four runs of five samples each were made for each of the three types of starches. Each run was set up as follows. Two cups of the prepared starch were put in each of four, two quart glass bowls. The bowls were labeled with adhesive tape bearing the numbers one, two, three and four. Five cotton samples were placed in bowl one. The starch solution was squeezed through by hand manipulation, ten times. The samples were then wrung by hand to remove excess starch and were hung separately to dry. The same procedure was followed for bowls two, three, and four, giving a total of twenty samples. The samples were hung as they were taken from the starch solution on indoor clothes racks for drying in a warm room.

At the end of two hours they were sprinkled evenly with warm water from a clothes sprinkler, then placed loosely in plastic bags. The amount of moisture added and the interval between dampening and ironing were kept constant.

The dampened fabrics were ironed first on the wrong side and then turned and pressed on the right side with a thermostatically controlled hand iron. The manufacturer's recommended temperatures were used; namely, \((325^\circ \text{F} - 375^\circ \text{F})\) for the powdered and liquid starches and \((275^\circ \text{F} - 325^\circ \text{F})\) for the plastic starch. After ironing, the samples were hung up and permitted to dry for twenty-four hours before being judged.

Four photometer readings were made of the stiffened samples starting at the upper left corner reading left to right. Meter readings ranged from a zero to an 84. Black was indicated by a zero and
white indicated by an 84.

Judging

The stiffened samples were evaluated for change in color, luster, and hand by a panel of three selected well trained judges. The fifteen inch experimental squares were arranged in groups according to the type of stiffening agent used.

Each judge scored each sample of each run of each class of starch against the original sample for change in color, luster and hand and recorded her findings on a score card prepared for this purpose. The investigator collected the score cards after each judging.

The score cards were so designed that the judges could record four degrees of change for each factor studied. These degrees were, no change, slight change, moderate change, and considerable change. The scoring card is shown on page 1 in the appendix. The directions for scoring were as follows: if there was no change, a zero was placed in the appropriate column; a slight change, one was placed in the appropriate column; for a moderate change, two was placed in the appropriate column; and for considerable change, three was placed in the appropriate column.

Experiment II, Starch Accessories

The procedure for preparation of the fabric samples for
part two was the same as for part one. Powdered starch was selected as the experimental starch for part two, since it was the cheapest one and the one customarily used in the homes. The seven accessories used were borax, instant tea, salina, dye, bluing, glycerine and a solvent.

For each accessory two solutions of powdered starch were prepared according to the manufacturer's directions, one using tap water and the other using distilled water. Preparation of basic starch solution was in the following manner. Two tablespoons of starch were dissolved in one-half cup of cold water and mixed until creamy. To this was added two quarts of boiling tap water. The solution was stirred constantly with a wooden spoon until it gave a clear appearance. The starch solution was covered and permitted to stand until it reached room temperature. It was then strained through a cloth bag before using.

The second solution was prepared in the same manner except that distilled water was substituted for tap water.

Addition of accessories

1. Borax: Two teaspoons of borax were added to the basic starch solution before the solution was cooled. The solution was stirred with a wooden spoon until well mixed.

2. Instant tea: One tablespoon of instant tea dissolved in one-fourth cup of boiling water was added to the hot starch solution and stirred until well mixed.

3. Salina: Eight grams of salina were added to the hot starch solution and stirred until well mixed.
4. Dye: Two tablespoons of dark green all purpose dye were dissolved in one-fourth cup of boiling water and added to the hot starch solution.

5. Blueing: One teaspoon of blueing dissolved in two tablespoons of luke warm water was added to the hot starch solution and stirred until well mixed.

6. Glycerine: Two tablespoons of glycerine were added to the hot starch solution and stirred until well mixed.

7. Solvent: The basic solutions were prepared in the same manner as stated for borax. The solution was covered and allowed to stand until it reached room temperature and was strained through a cloth bag. One tablespoon of solvent was put in each of four glass bowls and two cups of the basic starch solutions were added to each bowl. The mixtures were thoroughly mixed and the samples were starched immediately.

Stiffening of Samples

In the stiffening procedure, four runs of five samples each were made for the hard water and distilled water solution for each accessory. The procedure used for stiffening, drying, sprinkling, and ironing were the same as described for the powdered starch in Experiment I.

The stiffened samples were evaluated for change in color, luster, and hand as described for Experiment I.
Experiment III, Commercial Stiffening Agents

The samples of material to be used in the experiment were prepared as described in Experiment I.

The three commercial agents used were resin 110, resin 120, and resin 159. Each was prepared according to the manufacturer’s directions. The recommended amount of the agent was poured into a four-quart container and into this, water was added, mixed thoroughly, and permitted to stand until it reached room temperature. The dark cotton material was stiffened, dried, sprinkled, and ironed by the customary home procedure. The proportions of water and resin were used as follows:

1. Resin 110
   One-third cup of resin.
   Two quarts of water at room temperature.

2. Resin 120
   Three-fourths cup of resin
   Two quarts of water at room temperature.

3. Resin 159
   Three-fourths cup of resin.
   Two quarts of water at room temperature.

The procedures for stiffening the samples, the drying, the ironing, and judging were the same as described in Experiment I.

Experiment IV, Permanent Finishes

The sixty samples used for this part of the study represented
three permanent finish cottons supplied by three different finishers. In the experiment the samples were washed in an automatic washer at medium temperature (110° F - 112° F). To each wash one-fourth cup of all purpose detergent was added. After ten washings the samples were taken from the machine dried, sprinkled, ironed, and judged as described in Experiment I. The samples were evaluated for change in color, luster, and hand after ten, twenty, thirty, forty, and fifty washings. Thus, the last evaluation of the samples was at the end of fifty washings which would be considered the equivalent of a garment being laundered practically every week for a year.

**Validity of Judging**

The three judges were a Clothing and Textiles college teacher, and two graduate students in the Clothing and Textiles field. This type of judging was a new experience for the graduate students. The judging was done independently. Slight differences were shown between the judges in scoring the separate runs of the three classes of starches and the commercial stiffening agents. For no run was there a significant difference in the rating of the judges. Most of the flexibility in the judging was in the graduate students and in each case one graduate student always agreed with the teacher. Judge one and three rated the three classes of starch similarly while judge two and three scored the commercial stiffening agents approximately the same.

The difference in scoring may be due to factors other than
experience. The standards for rating were not clearly defined by the investigator and a preparatory period for judging was not held. Although the judges had original samples against which to evaluate the experimental samples their judgment had to be subjective.

**Meter Readings**

It was felt that the judges reacted more sensitively to slight color changes than the photovolt reflection meter readings. Since the readings were recorded by whole numbers, slight changes were difficult to determine. Fractions of numbers on the photovolt reflection meter would aid in recording slight changes. Another problem was the fact that the meter recorded change from dark to light. Although the starch may have not made a significant change from darkness to lightness in the color of the material, it could be unacceptable to the user due to the white spotting of the starch.

**Limitation of the Study**

It is realized that this study has certain limitations.

1. The study of the suitability of the recommended stiffening agents was made on dark green cotton. This study proceeded on the premise that a stiffening agent effective for dark green cottons would be equally effective for all dark cottons. No attempt was made to judge the suitability of the stiffening agents on the other colors of dark cottons.

2. The three classes of starches for the study were obtained from the
stores in Blacksburg, Virginia. The starches were selected at random. No attempt was made to evaluate the comparative effectiveness of the several starches of each class on the market.

3. Stiffening agents used commercially were secured from one manufacturer for the study. The manufacturer was asked to submit any stiffening agent which they felt could be safely adapted to home use. The extent to which the manufacturer gave a complete picture of their stiffening agent is not known. They, on the whole, were very cooperative and the investigator had every reason to believe that the stiffening agents secured for the study were those considered the most adaptable to home use by the manufacturer.

4. A preparatory period for training the judges was not held to validate their scoring. Such a training period may have eliminated some differences in judgment on the part of the judges.
CHAPTER II

SUITABILITY OF AVAILABLE STIFFENING AGENTS
FOR DARK COTTONS

This study resulted from the need expressed by homemakers for a suitable method of restoring dark cottons to their original appearance after home laundering. Dark cottons for apparel purposes, although relatively new in the clothing industry, are greatly in demand. The type of stiffening agents customarily used on light cottons shows up white on dark cottons after ironing. Help in overcoming this problem in using the customary stiffening agent, or the finding of a new stiffening agent for dark cottons, is being demanded by the homemakers.

The first step in overcoming this problem appeared to be that of studying the suitability for dark cottons of the stiffening agents on the local market recommended for use in home laundering. The types of starches found in the local market were powdered starch, synthetic liquid, and non-synthetic liquid starch. Thus, these three types were used in this experiment.

The starches were prepared and used according to the manufacturer's directions. (See page 7 for details).

In evaluating the three classes of starches for dark cottons, the assumption was made that the most desirable starch would give a stiffened product after laundering, most similar in all respects to the original.

The three starches used were rated in the following order for
suitability by the three judges.

First or most desirable: plastic starch
(Class III in experiment).
Second: non-synthetic liquid starch
(Class I in experiment).
Third or least desirable: powdered starch
(Class II in experiment).

There was a significant difference in the rating of the three starches as to the degree of change in color, luster, and hand for each of the three judges. In each case the F value for Chi square was smaller than 0.001, indicating that the probability of the difference in the three starches noted by the judges being due to chance alone was less than one in a thousand.

The plastic starch was effective on the dark cottons. It produced a clear, stiffened product. It was relatively easy and safe to use. It left a rich substantial finish. Instead of merely coating the surface of the fabric as powdered starch does, plastic starch appeared to penetrate the inner fibers that make up each thread.

Although the plastic starch gave a very satisfactory product it has several disadvantages when considered for home use. The use of plastic starch adds additional steps in the laundering process which are costly in time and money. The clothes must be dry or nearly dry before the plastic starch is applied to permit maximum pick up of the starch solution. Again they must be thoroughly dry before sprinkled for ironing. If not, the plastic starch sticks to the iron and the
resulting garment is slightly limp. This adds one extra drying process to the ordinary laundering operation. For those garments usually rolled up damp, another drying and also sprinkling process is required.

The plastic starch is not suitable for use when a heavy starch is desired on parts of a garment such as collars and cuffs. Partial heavy starching produces a visible line of demarcation between the treated and untreated portions of the garment. This line of demarcation was very pronounced on dark cottons.

Plastic starch lasts through 12 - 15 washings. In order to have the desired stiffness over several washings, clothes must be considerably stiffer the first time when plastic starch is used, since the greatest loss in the effectiveness of the plastic starch is at the first washing. However, there is a gradual reduction in the stiffness with each recurring washing. Thus it is impossible to maintain uniform stiffness throughout all washings.

Another disadvantage for many homemakers is the fact that for the first application of plastic starch the garments cannot be dried in a commercial dryer. If dried in a commercial dryer, plastic starch adheres to the inside of the dryer. Also, the garments lose much of their stiffness. Once the stiffened clothes have been ironed and washed, they present no further problems when dried in a commercial dryer.

The homemaker needs to keep a record of the number of times each garment is washed after the application of plastic starch. The amount of stiffness in a freshly washed and dried garment cannot be
Table 1

Comparison of Stiffened Material with Original for Three Stiffening Agents

Judge 1

<table>
<thead>
<tr>
<th>Starch class</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>28</td>
<td>0</td>
<td>14</td>
<td>42</td>
</tr>
<tr>
<td>II</td>
<td>60</td>
<td>28</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>III</td>
<td>15</td>
<td>40</td>
<td>19</td>
<td>74</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>103</strong></td>
<td><strong>63</strong></td>
<td><strong>45</strong></td>
<td><strong>216</strong></td>
</tr>
</tbody>
</table>

$x^2 = 57.06$

$P < 0.001$

*The scores under color, luster, and hand are the sum of the scores for twenty samples. Smaller numbers indicate less change than larger numbers. The scoring was as follows: Zero equals no change, 1 equals slight change, two equals moderate change, and three equals considerable change. Thus Judge one under color scored starch one zero, two times, one, eight times and two, ten times giving a total of twenty-eight for the twenty samples. Starch two was scored three, twenty times giving a score of 60. Starch three was scored zero, fivetimes and one, fiften times giving a total of fifteen. This explanation holds for Tables 1 through 11.*
Table 2
Comparison of Stiffened Material with Original for
Three Stiffening Agents

Judge 2

<table>
<thead>
<tr>
<th>Starch Class</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>20</td>
<td>34</td>
<td>26</td>
<td>80</td>
</tr>
<tr>
<td>II</td>
<td>60</td>
<td>60</td>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>III</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>114</td>
<td>106</td>
<td>300</td>
</tr>
</tbody>
</table>

\[ x^2 = 4.79 \]

\[ P \ll 0.001 \]

Table 3
Comparison of Stiffened Material with Original for
Three Stiffening Agents

Judge 3

<table>
<thead>
<tr>
<th>Starch class</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>39</td>
<td>13</td>
<td>20</td>
<td>63</td>
</tr>
<tr>
<td>II</td>
<td>69</td>
<td>40</td>
<td>40</td>
<td>149</td>
</tr>
<tr>
<td>III</td>
<td>8</td>
<td>20</td>
<td>40</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>73</td>
<td>100</td>
<td>256</td>
</tr>
</tbody>
</table>

\[ x^2 = 26.73 \]

\[ P \ll 0.001 \]
Restoring Dark Cotton to Original Stiffness

Original sample

Liquid non-synthetic starch

Powdered starch

Plastic (or synthetic) starch

Figure 1
determined by the hand before it is ironed. This necessitates careful evaluation and marking of garments needing starching before the washing process begins. Such discrimination would preclude help from family members or others who were not experienced in making these judgments. Also this would prevent the occasional sending of clothing outside the home for laundering.

The plastic starch is difficult to remove. If by mistake a very heavy starching is administered, or the wrong garment is starched, the excess stiffness can be removed by numerous washings or by soaking the garment in ethyl alcohol for one hour or more. In addition, the garment must be rubbed by hand until it no longer feels slippery while immersed in the alcohol. In view of the fact that ethyl alcohol is expensive, evaporates quickly, and is inflammable, this procedure can not be recommended for home use.

Another disadvantage is that the first ironing after application emits unpleasant odors. Although this may not be a disadvantage to one it would be very disagreeable to others.

The judges ranked the non-synthetic liquid starch second to plastic starch in effectiveness, for dark cottons. It had a tendency to spot the material on the side the fabric was first ironed. The heat of the iron brought white spots to the surface of the material. This makes it necessary for dark garments to be ironed completely dry on the wrong side and then turned and pressed on the right side.

Another disadvantage is that it is more expensive than the other two starches used. Its initial cost was five cents a quart for
prepared starch as compared to three cents for plastic starch and one cent for powdered starch. Also it is removed in the washing process which necessitates fresh starching of all garments after each washing. It gives the fabric a glossy finish which is objectionable for some fabrics.

The non-synthetic liquid starch was found to have certain advantages. Its preparation was very easy. The concentration of liquid starch needs only to be diluted with warm water before using. The water mixes very easily with the starch. There is no tendency to lump or separate out. The starch contains an ironing aid which gives the fabric a glossy finish and appears to reduce the ironing effort. The starch is free of unpleasant odors during treatment and ironing. It is easy to remove from the garment since it is completely removed by washing. It can be applied to damp clothes and the stiffened garments need not be completely dried before ironing.

The chief advantage of the powdered starch is that it is economical. The cost is one cent per quart of prepared starch as compared to three cents for plastic and five cents for non-synthetic liquid starch. It is suitable for use in any concentration: light, medium or heavy. Also it is suitable for stiffening parts of the garment such as cuffs and collars without immersing the entire garment. It gives a stiffer finish to fabrics than does a heavy concentration of the non-synthetic liquid starch. It is free of unpleasant odors during treatment and ironing. It is easy to remove since it washes out evenly in either hot or cold water.
The powdered starch was not suitable for dark cottons. Powdered starch showed up white on dark cottons after ironing. The judges rating the samples considered the appearance very undesirable.

The powdered starch is more difficult to prepare than the ready prepared starches. It requires three steps in making: it must be dissolved in cold water to which is added boiling water. The solution must be permitted to stand until it reaches room temperature and strained before using. Powdered starch cannot be stored for subsequent use which requires making new starch each time garments are to be starched.
Summary

The experimental work on powdered, synthetic and non-synthetic liquid starch showed the plastic starch to be the most effective for dark cottons in restoring them to their original stiffness after laundering. The non-synthetic liquid starch was not as desirable as the plastic starch. The starch spotted the fabric on the side that was ironed first. Powdered starch was not desirable for dark cottons due to the fact that the cottons were left spotted and retained a white appearance.

Although the initial cost of plastic starch is relatively high, it is economical in the long run since garments need to be starched only once in twelve to fifteen washings. Due to the extra steps required in the laundering process, the need for keeping records on the number of times the garments are washed after each application of plastic starch, the difficulty in controlling the amount of stiffness in garments, and the great difficulty in removing excess stiffness, the plastic starch was judged inappropriate for the average homemaker's use.
CHAPTER III

ADAPTATION OF POWDERED STARCH FOR STIFFENING DARK COTTON IN HOME LAUNDRYING

Powdered starch, being the most economical and that most customarily used by the homemakers, was selected for further study in an attempt to make it effective on dark cottons by the use of accessories.

In the experimental work seven different accessories were added to the powdered starch: namely, borax, tea, satin, dye, bluing, glycerine and a solvent. Two solutions of powdered starch were prepared for each of the seven accessories, one using tap water and the other using distilled water (See Page 10 for details). The powdered starch solution with either glycerine or borax, when added, produced a stiffening solution judged suitable for dark cottons. The borax and glycerine solutions gave a rich substantial finish free of white spotting. Although the judges rated the plastic starch slightly superior in color to the borax and glycerine, they rated the borax and glycerine solutions somewhat better than the plastic starch in luster and hand. This research indicates that the addition of either borax or glycerine to powdered starch will render it effective for home laundering of dark cottons.

The borax and glycerine solution have the additional advantage of being safe to use and adaptable in any concentration desired. The solutions can be applied to the entire garment or parts of the garment successfully without any visible line. They can be applied
to either a wet or dry garment. When applied to the dry garment, the absorption of starch is greater, and therefore a stiffer garment is produced.

Although borax and glycerine gave similar products when added to the powdered starch, the borax solution seems to be the most advisable for home use due to its economy. Borax can be added to the starch solution for less than one-half cent per quart while the addition of glycerine would cost approximately five cents per quart. /2

There seems to be no advantage to adding to a basic powdered starch solution the following accessories: blueing, satina, tea, dye, and a solvent. The three judges scored each of the stiffening solutions containing the above accessories as undesirable for dark cottons. The accessories did not prevent the spotting of the fabric which was characteristic of the powdered starch.

/2 To ascertain the feasibility of the manufacturer's adding borax to powdered starch in the manufacturing process, the investigator put into a glass bowl twelve tablespoons of powdered starch and twelve teaspoons of borax. The ingredients were stirred with a wooden spoon until well mixed and permitted to stand uncovered fourteen days. At the end of this period a basic starch solution was prepared using two tablespoons of powdered starch and borax mixture. The directions as set up by the powdered starch manufacturer were used (see page 7 for details.) The investigator found the powdered starch and borax material to be more difficult to dissolve than the plain powdered starch, but the solutions was equally as desirable for stiffening dark cottons. It is believed that the manufacturers could find a means of overcoming the slight difficulty in adding borax to the powdered starch during the manufacturing process.
Table 4

Comparison of the Effectiveness of the Plastic Starch and the Powdered Starch Plus Borax

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class III</td>
<td>3</td>
<td>27</td>
<td>33</td>
<td>68</td>
</tr>
<tr>
<td>Borax</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>47</td>
<td>60</td>
<td>135</td>
</tr>
</tbody>
</table>

\[ X^2 = 6.77 \]

\[ P \approx 0.20 \]

Table 5

Comparison of the Effectiveness of the Plastic Starch and the Powdered Starch Plus Glycerine

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class III</td>
<td>3</td>
<td>27</td>
<td>33</td>
<td>63</td>
</tr>
<tr>
<td>Glycerine</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>47</td>
<td>60</td>
<td>135</td>
</tr>
</tbody>
</table>

\[ X^2 = 6.77 \]

\[ P \approx 0.20 \]
Table 6
Comparison of Powdered Starch with Borax in Distilled and Tap Water Solutions

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borax distilled water</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>67</td>
</tr>
<tr>
<td>Borax tap water</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>40</td>
<td>54</td>
<td>134</td>
</tr>
</tbody>
</table>

$X^2 = 0$

$P \approx 0$

Table 7
Comparison of Powdered Starch with Glycerine in Distilled and Tap Water Solutions

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycerine distilled water</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>47</td>
</tr>
<tr>
<td>Glycerine tap water</td>
<td>20</td>
<td>20</td>
<td>27</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>40</td>
<td>54</td>
<td>94</td>
</tr>
</tbody>
</table>

$X^2 = 0$

$P \approx 0$
Powdered Starch with Accessories

Original sample

Powdered starch

Powdered starch
plus borax

Powdered starch
plus glycerine

Figure 2
Starch Solution Plus Borax Made with Distilled and Tap Water

Original sample

Powdered starch without borax

Powdered starch with tap water

Powdered starch with distilled water

Figure 3
Hard Water and Distilled Water

It is a generally accepted belief on the part of homemakers that the spotting from powdered starch solutions prepared with tap water is due to the volatile salts in the water. To test this belief the effectiveness of the powdered starch when in tap or distilled water solutions was studied. The experimental work showed that powdered starch solutions prepared with either tap or distilled water were undesirable for dark cottons. There was more spotting from the distilled water than the tap water. Powdered starch solutions containing borax and glycerine were equally desirable for dark cottons in tap water and distilled water. On the other hand powdered starch solutions containing satina and a solvent spotted the dark fabric in distilled water the same as in tap water.

In the case of blueing and dye, the distilled water showed more spotting while with tea it showed slightly less. But in all cases the stiffened products remained undesirable.

Summary

The experimental work with powdered starch solution containing the following accessories: borax, tea, satina, dye, blueing, glycerine and a solvent showed that with the addition of glycerine or borax powdered starch was effective for stiffening dark cottons.

On the other hand, tea, satina, dye, blueing and a solvent when added to the powdered starch did not improve its suitability for
dark cottons. Distilled water showed no advantage over tap water in the making of starch solutions.
CHAPTER IV

ADAPTATION OF COMMERCIAL STIFFENING AGENTS FOR DARK COTTONS IN HOME LAUNDRING

A pleasing hand and an attractive appearance play important roles in the selection of fabrics by consumers. Manufacturers have long recognized these needs and extensive research is being done to improve the qualities of cotton fabrics. The unfortunate factor is that most cotton fabrics do not retain these qualities to the same degree after laundering.

In view of the problem, selected commercial stiffening agents were experimented with to ascertain their suitability under home laundering conditions.

Upon request, one commercial company sent to the investigator three products used commercially in the finishing of cottons, namely, resins 110, 120, and 159. None of these are on the local market for home use.

Resin 110 is a thermoplastic synthetic resin of the alkyd type prepared as a water dispersible emulsion. Resin 120 is a water dispersible, anionic emulsion of a thermoplastic resin of a modified acrylate type. Resin 159 is a water dispersible emulsion of polyvinyl acetate resin. The commercial stiffening agents were used according to manufacturers' directions in so far as possible. However, in the use of the resins, factory conditions could not be duplicated in the home. The manufacturer's directions for using the resin stated that the following factors would influence the success in using.
1. The type of fabric to be handled.

2. Conditions of fabric prior to finishing.

3. Equipment available for the use.

The manufacturers maintain that the most satisfactory results are obtained when the fabric is padded and then dried at 250° F - 300° F for one to three minutes. This means that the fabric is run through a bath of the solution in a padding machine, squeezed through rollers, and then run through a tendering frame. While still in the frame, it passes into enclosed chambers where hot circulating air dries the fabric under exact temperature control. Under these conditions a finish is produced which is more durable in laundering than is obtained by a low drying temperature. If a slight luster is desired, the fabric is run against a steel roller.

In order to study the effectiveness of these resins for home use, the dark cotton materials were stiffened in the solution, dried, sprinkled, and ironed by the customary home procedure.

All three commercial resins stiffening agents were rated undesirable by the judges, however, there was a significant difference in the rating of the three stiffening agents. Resin 110 was more desirable than the other two, while 159 was the least desirable.

The undesirability resulted from the tendency of these materials to spot the fabric rather than from color change. In addition to the spotting, resin 159 had a very undesirable hand.

The resins used gave a stiffer hand than the original sample. Manufacturers add softening compounds such as waxes and oils to the
**Table 8**

Comparison of Stiffened Material with Original Sample for Three Commercial Stiffening Agents

Judge 1

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>28</td>
<td>20</td>
<td>20</td>
<td>68</td>
</tr>
<tr>
<td>120</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>159</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td>80</td>
<td>120</td>
<td>268</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 16.13 \]

\[ P \sim 0.001 \]

**Table 9**

Comparison of Stiffened Material with Original Sample for Three Commercial Stiffening Agents

Judge 2

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>20</td>
<td>20</td>
<td>24</td>
<td>64</td>
</tr>
<tr>
<td>120</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>159</td>
<td>20</td>
<td>20</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>80</td>
<td>104</td>
<td>244</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 29.47 \]

\[ P \ll 0.001 \]
Table 10

Comparison of Stiffened Material with Original Sample for Three Commercial Stiffening Agents

Judge 3

<table>
<thead>
<tr>
<th>Stiffening Agent</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>120</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>159</td>
<td>20</td>
<td>20</td>
<td>43</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>80</td>
<td>103</td>
<td>243</td>
</tr>
</tbody>
</table>

χ² = 20.70

p = 0.001
Commercial Stiffening Agents

Original sample

Resin 110

Resin 120

Resin 159

Figure 4
stiffening agents which aid in producing a pleasing hand. Other substances, like glucose, may be added to prevent the stiffening agents from becoming too dry and harsh. The home does not have the facilities for reproducing these methods.

In addition the commercial resins are perishable and must be stored air-tight at a temperature between 40° F - 70° F which many homemakers may find difficult.

They emit unpleasant odors during application and ironing which may be offensive to many homemakers.

**Summary**

The experimental work on three resins used commercially for stiffening and finishing cottons indicated that they were not satisfactory for home use. Home laundry methods produced a spotted stiffened product as compared with the original.
CHAPTER V

EFFECTS OF WASH LAUNDERING ON PERMANENT FINISH COTTONS

In an effort to increase the competitive status of dark cottons with nylon, orlon, dacron, and with other man-made fibers, manufacturers are attempting to give cotton a permanent stiffness during finishing similar to that of the man-made fibers where the stiffness results from the weaving process. Cotton fabrics so treated require no starching. Upon ironing, the laundered fabric returns to its original crispness with no limpness. The treated starchless fabric gives a reasonably permanent hand under ordinary conditions of use.

Only a few manufacturing concerns are giving a permanent finish to dark cottons, but it is reasonable to assume that most manufacturers will be forced into it due to the competition.

The permanent finish fabric is comparatively expensive as compared to the non-permanent finish. Since the finish increases the serviceability of the fabric and makes its upkeep more convenient and economical, many homemakers are willing to pay the additional cost. However, they are desirous of knowing how permanent the hand of starchless fabrics is under home laundering conditions. No research was found in the published literature dealing with the problem.

In response to an inquiry made by the investigator concerning the permanence of the so-called permanent finishes, one manufacturer said, "It is our objective that these finishes, properties, should be completely permanent for the life of the garment, and a great deal of
progress has been realized in the last few years in achieving such a degree of permanence."

In a letter from another finisher, the following explanation of permanence finish is given. "The word permanent is a misnomer which is applied to the use of resin finishes. The term is used to show a difference between resin finish and finishes which wash out almost immediately."

In studying the behavior of the so-called permanent finishes, three dark fabrics, namely, a navy blue printed, medium weight cotton, a solid navy blue, medium weight cotton and a dark green solid, medium weight fabric, each from a different finisher were subject to home laundry conditions, i.e. they were washed in an automatic washer using warm water and an approved detergent. The samples were washed a total of fifty times which is considered the equivalent of the laundering given a house dress during a year.

Samples were scored after each ten launderings, i.e. after ten, twenty, thirty, forty, and fifty for the degree of change in color, luster, and hand.

After the fifty launderings the judges found only a slight change in luster and hand of the permanent finish materials. All of the fabrics maintained sufficient stiffness. The slight change in stiffness occurred during the first ten washings in so far as could be determined. In the case of color, two of the fabrics showed only a slight change. This change occurred during the first ten washings and probably was due to the washing out of the excess dye. The third material showed
Table II

Comparison of the Permanent Finish of Three Cottons
After Fifty Washings as Compared to the Original

<table>
<thead>
<tr>
<th>Finisher</th>
<th>Color</th>
<th>Luster</th>
<th>Hand</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabric I</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Fabric II</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Fabric III</td>
<td>50</td>
<td>25</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>75</td>
<td>75</td>
<td>250</td>
</tr>
</tbody>
</table>

$\chi^2 = 6.63$

$p < .0001$
Retention of Permanent Finish Under Home Laundering Conditions

Original sample          After 50 washings

Original sample          After 50 washings

Figure 5
Retention of Permanent Finish Under Home Laundering Conditions

Original sample  After 50 washings

Figure 6
only a slight change in color through the thirtieth washing but a moderate change in color after that.
CHAPTER VI

SUMMARY AND CONCLUSIONS

Dark cottons are becoming popular for wearing apparel. Powdered starch customarily used in the home for restoring stiffness to cottons after laundering produces a spotted white product when used on dark cottons. Thus, homemakers are demanding information on ways to restore dark cottons to the original stiffness after laundering. There was no research in the published literature available to the investigator which was designed to answer this problem.

The purposes of this study were fourfold.

1. To test the suitability for dark cottons of the stiffening agents available to consumers on the local market for restoring stiffness to cottons.

2. To experiment with procedures for increasing the suitability for dark cottons of powdered starch by the addition of accessories.

3. To experiment with selected stiffening agents used commercially on dark cottons to study their suitability for home laundering.

4. To test selected dark cottons with permanent finishes to study their finish retention quality under home laundering conditions.

Four cotton fabrics, namely, dark green wrinkle-shed cotton, a dark green Indian head, a medium weight solid navy blue permanent finish cotton, and a medium weight navy blue printed permanent finish cotton were used in this study. The fabrics were cut into fifteen
inch squares and labeled with cloth indelible marking ink.

The data on the degree of change in color, luster and hand were obtained by a panel of judges. The data were recorded on schedules especially designed for this purpose.

The experimental work on the suitability of the stiffening agents on the local market for dark cottons showed that:

1. Plastic starch was the most effective for dark cottons in restoring their original stiffness. It gave a rich substantial finish very similar to the original stiffness. Plastic starch was found to have the following disadvantages. It required extra steps in the laundering process and the keeping of records on the number of times the garments were washed after each application of plastic starch. It was difficult to control the amount of stiffness in garments. Excess stiffness in the garment could be removed only by many washings or the use of ethyl alcohol.

Both the non-synthetic liquid starch and the powdered starch were judged undesirable for dark cottons.

2. Although the powdered starch and non-synthetic liquid starch were unsatisfactory for stiffening dark cottons, both proved satisfactory when either borax or glycerine were added to the solution. When borax and glycerine were added, they produced a rich substantial finish free of white spotting. The other accessories, namely, tea, satina, dye, blueing and a solvent had no appreciable effect on improving the suitability of the powdered and liquid non-synthetic starch. Distilled water showed no advantage over tap water in the
making of starch solutions.

3. The three resins used commercially for stiffening of dark cottons selected for the study were not satisfactory for home use. Home laundry methods produced a spotted stiffer product as compared with the original.

4. In subjecting the permanent finish cottons to home laundering procedures, it was found that after fifty washings there was only a slight change in luster and hand for all three permanent finish fabrics. In the case of two fabrics the color change was only slight, while for the third fabric the color change was moderate with a tendency to streaking.
RECOMMENDATIONS

In view of the findings in this study, the following recommendations are made:

1. Manufacturers should be encouraged to add borax to the powdered starch to make it suitable for both dark and light cottons since the average homemaker finds it more convenient to use one starch for all materials. Likewise, non-synthetic liquid starch manufacturers should advise in their directions for the using of borax and glycerine, when the starch is to be used for dark cottons.

2. Since dark cottons are coming into prominence for apparel wear, home economics teachers and extension workers, and home economists working with laundering equipment should inform homemakers on procedures for starching dark cottons.

3. In view of the fact that there is very little published literature concerning the questions raised in this study, it is recommended that a similar study be carried out using a larger sampling of dark cottons to verify the results of this study.

4. Where cost will permit, it is recommended that dark cottons used for women's and children's wearing apparel be finished so as to have a permanent stiffness and crease resistant quality in keeping with the characteristics of the fabric line. Furthermore that the label on the materials describe the characteristics of the materials and advise as to suitable methods of laundering.
ACKNOWLEDGMENTS

The author wishes to express her sincere appreciation to all those who have helped to make this study possible. To Doctor Mildred Thurow Tate for her guidance and personal interest throughout the study; Miss Oris Glisson for her suggestions, encouragement and time devoted as a judge; and Lilly Fu and Carla Estes for serving as judges. The author deeply appreciated the assistance of Professor Unus Earp on the study and the use of certain equipment provided by him. To the Dan River Mills, H. and W. Thomas Company, D. B. Fuller, Incorporated, who provided fabrics for testing and to the American Cyanamid Company for resins used in this study, the investigator expresses her deepest thanks.

E.L.G.
BIBLIOGRAPHY


VITA

Emma Lusetta Gough was born at Rustburg, Virginia. She obtained her elementary and high school education at Rustburg High School. She received her Bachelor of Science Degree in Home Economics from Virginia Polytechnic Institute in June 1948.

After graduation she held a position with the Virginia Agricultural Extension Service for approximately six years. During her employment she served 14 months as Assistant Home Demonstration Agent and the remainder of the time as Home Demonstration Agent.

In June 1954 she entered Virginia Polytechnic Institute to do graduate work.

[Signature]
Emma Lusetta Gough
**SCORE CARDS.**

Restoring of Dark Cottons to Their Original
Stiffness After Laundering

<table>
<thead>
<tr>
<th>Judge</th>
<th>Exp.</th>
<th>Run</th>
<th>Sample No.</th>
<th>Stiffening Agent</th>
<th>Accessory</th>
</tr>
</thead>
</table>

Change in Appearance

<table>
<thead>
<tr>
<th>1. Color</th>
<th>None</th>
<th>Slight</th>
<th>Moderate</th>
<th>Considerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Luster</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Hand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks:

Restoring of Dark Cottons to Their Original
Stiffness After Laundering

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Run</th>
<th>Sample No.</th>
<th>Stiffening Agent</th>
<th>Accessory</th>
</tr>
</thead>
</table>

Before laundering | After laundering | Change

1. Photovolt reflection
   meter readings
   1. 
   2. 
   3. 
   4. 

2. Weight reading
   1. 

   | | | |
   | | | |
   | | | |
   | | | |
Explanation of $\chi^2$

The extent to which the difference between the suitability of the three starches was due to factors other than chance was measured by $\chi^2$. In other words, the $\chi^2$ test is applied to determine the independence of the factors tested. $\chi^2$ is found by using the following formula:

$$\text{Ex. N.} = \frac{\text{Column Total x Line Total}}{\text{Total Number}}$$

$$d = \text{Obs.}$$

$$d^2 = d \times d$$

$$rd = \frac{d^2}{\text{Ex. N.}}$$

$$\chi^2 = \sum \text{R. D.}$$

(Obs.) observed number, (Ex. N.) frequency expected, (d) deviation, (d$^2$) deviation squared, (rd) relative difference, and ($\chi^2$) chi square.
The following table illustrates the finding of $x^2$ for

Table I page 19:

Table 1. Comparison of Stiffened Material with Original for
Three Stiffening Agents

<table>
<thead>
<tr>
<th>Starch Class</th>
<th>Obs. N.</th>
<th>Exp. N.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>23</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>20.02</td>
<td>13.22</td>
<td>8.75</td>
</tr>
<tr>
<td></td>
<td>9.98</td>
<td>13.22</td>
<td>5.25</td>
</tr>
<tr>
<td></td>
<td>63.68</td>
<td>174.77</td>
<td>27.56</td>
</tr>
<tr>
<td></td>
<td>3.18</td>
<td>13.22</td>
<td>3.15</td>
</tr>
<tr>
<td>II</td>
<td>60</td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>47.63</td>
<td>31.43</td>
<td>20.33</td>
</tr>
<tr>
<td></td>
<td>12.32</td>
<td>3.43</td>
<td>3.33</td>
</tr>
<tr>
<td></td>
<td>151.73</td>
<td>12.11</td>
<td>77.97</td>
</tr>
<tr>
<td></td>
<td>3.13</td>
<td>3.35</td>
<td>3.74</td>
</tr>
<tr>
<td>III</td>
<td>15</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>39.25</td>
<td>23.33</td>
<td>15.42</td>
</tr>
<tr>
<td></td>
<td>24.25</td>
<td>16.70</td>
<td>3.58</td>
</tr>
<tr>
<td></td>
<td>588.06</td>
<td>278.89</td>
<td>12.32</td>
</tr>
<tr>
<td></td>
<td>14.93</td>
<td>11.97</td>
<td>.83</td>
</tr>
</tbody>
</table>

Total | 103 | 68 | 45 | 216

$$x^2 = 3.18 + 13.22 + 5.15 + 3.13 + 3.35 + 3.74 + 14.93 + 11.97 + .83$$

$$x^2 = 57.06$$
The probability factor (P) indicates whether or not \( x^2 \) is significant; i.e., it indicates whether or not the association between the variables may be due to chance. For example, a "P" value of .20 means that in twenty out of 100 cases the association could be due to chance alone. If "P" is equal to or smaller than (\(<\) 0.05, \( x^2 \) is considered significant. This means that there would be less than five chances in 100 that the indicated association could be due to chance (13).