THE EFFECT OF DIFFERENT TYPES OF STARCHES ON THE STIFFNESS AND CREASE RECOVERY OF A COTTON FABRIC

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Most affectionately dedicated

to my father.

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CHAPTER I

INTRODUCTION

This research problem was done to study how different types of starches and different concentrations of these starches would affect the stiffness and crease recovery properties of a cotton fabric. The author was interested in a problem of this type because the cotton saris worn by women of Pakistan become limp and wrinkled at the end of short wearing period.

Out of many dresses worn by Pakistani women, the sari is the only dress which is well-known in the western world. There are many other types of dress worn by women both in East and West Pakistan; that is, the 'shalwar suit,' and 'garara' suit, etc. The different dresses have their varied cultural and historical explanations.

In West Pakistan the 'Shalwar Suit' is worn. It consists of a baggy trousers (shalwar), a long sheet-like dress (kamees) and a stole (dupatta) worn over the shoulders. The shalwar suit is usually worn by teenagers. The muslim court dress 'Garara Suit' is the national dress of women of Pakistan, at present. It is worn at formal occasions. The garara can be described as a long divided skirt, and it is worn with a short tunic (kurta) and a stole (dupatta). 'Garara Suit' is also a popular bridal dress in West Pakistan. Another dress worn here is fitted trousers worn with a flared tunic and a stole and is known as 'Tang-pajama suit.' This dress is suitable for daily wear. There are regional and tribal dresses which differ slightly from the above described dresses, that is, 'Sindhi' and 'Bluchi' dresses which are very much like 'Shalwar Suit.'

The sari is considered one of the most graceful and elegant oriental dresses. It is the most popular costume in East Pakistan for almost all occasions. In West Pakistan the sari is worn by professional women at work and also as an evening dress. Unlike many countries of the Middle East where western dress has been adopted for daily and evening wear, women of Pakistan are proud of their oriental costumes, and there seems to be no trend of adopting the western dresses.

The number of women, wearing saris is increasing very rapidly in Pakistan with the changes in economic and social status of women. The majority of educated women are entering into professions. If a woman does not already wear a sari regularly, she develops the habit of wearing it while at work. Basically, a sari is a straight piece of light weight fabric, usually with an embroidered, or printed pallo and border. The standard measurements for a sari are 42 to 45 inch wide and 6 to 6-1/2 yards in length. A sari is draped on the figure in a definite fashion and requires a blouse (choli) and a long slip to wear with it. The sari is usually made of light weight sheer silk, soft sheer synthetics or sheer cotton.

Today, cotton saris are worn by all classes of women and the wearing of cotton garments is being encouraged by public opinion. Pakistan is a cotton producing country and cotton material is an economical purchase. Therefore, in this country cotton is used in larger proportions than are other fibers. Use of cotton is also comfortable in the semitropical climate of Pakistan. In the past the cotton saris were worn mostly by lower and lower-middle class women. However, during the last few years there has been a trend towards using cotton even by the upper classes. This is primarily the result of a campaign to increase the patronage of the cotton industry, and also to eliminate wide economic gap among the people.

Cotton saris, though the fabric looks very beautiful and elegant, create some problems for the wearer. The sheer cotton sari, starched and ironed drapes well to start with, but the long hours used and humid climate causes it to crease and wrinkle and leaves it highly shabby at the end of the day.

As the sari is an untailored dress, part of its beauty depends upon the draping qualities of the fabric; the softer the fabric, the more easily and gracefully it will drape. At the same time a cotton sari must be starched in order to give it an adequate degree of smoothness, body and crease resistance, if it is to remain gracefully draped throughout the day. Therefore attention must be paid to the "cotton sari" and "starch" problem.

The present methods of starching in Pakistan are not very satisfactory. The most common types of starches available are rice starch and wheat starch. The starch is prepared by boiling rice or fine whole wheat flour with large amount of water. The starch is not prepared by any standard measurement, but that with which a particular person is acquainted or that which one thinks is right for a certain piece of fabric. Also the amount of starch used for a particular fabric depends usually on the will of housewife or the washerman.

Keeping in view the importance of starch and attainment of crease resistance quality the author was interested in finding out a suitable concentration of a starch which would give a cotton sari maximum degree of crease resistance with an adequate degree of body and smoothness.

Since application of starch greatly affects the draping qualities of cotton fabric by making it stiffer, the objectives of this study were:

1. To compare the effect of different types of natural, modified and synthetic starches on the stiffness of cotton fabrics.

2. To compare and evaluate the laboratory methods for measuring stiffness.

3. To compare the effect of starches on crease recovery.

Because of the amount of time available and being in a foreign country it was not possible to apply the above results to cotton saris. The author could not get the desired length of cotton sari fabric and so cotton batiste was used for experiments which was somewhat similar to cotton sari fabrics. The present investigations will help in future if a similar experiment is done on a cotton sari fabric of Pakistan in the following ways:

1. In finding out a suitable starch from the group of natural, modified or synthetic starches which would be effective for a longer period.

2. In determining the desirable concentration of a starch to give an adequate degree of crease resistance and body with minimum stiffness.

3. In determining standards of crease resistance and stiffness for cotton saris if it is to remain draped well, and look nice.

4. In finding out the effect of starch on such properties as soiling and ease of soil removal.

CHAPTER II

REVIEW OF LITERATURE

Starch

The use of starch has been known from time immemorial[1] and according to dePierre (Traite des Apprets, Paris, 1887, p. 14) it was even used as a textile finish in 800 B.C. However, its use appears to have been forgotten later except as a filling material.

About 1560, starch was again common in France and Holland as a means of stiffening the ruffles of the nobility. The use of starch became so popular for textile dressing that it had to be forbidden in 1600 and again in 1800.[2]

The early use of starch in textile industry was as a sizing in weaving. This practice was firmly established by about 1750. The next use which quickly followed was as a thickener in hand block printing.

At present, starch is used commercially as well as in the home to give body, crispness, and smoothness to cotton fabrics and garments. Jackman and Parker also mentioned that starched fabrics were less liable to retain dirt and consequently tend to keep clean for longer periods

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[1]Textile Colorists, "Starch and Starching," 60 (March 1944), 105-107.

[2]Ibid. p. 105-107.

than do unstarched materials.[1]

Source and Chemistry of Starch:

Starch occurs in large amounts in many roots and in cereal grains in which it has been stored by the plant as a reserve food supply for the use of growing plant of the next generation. The chief commercial sources of starch are wheat (which contains about 55 percent), maize (60 percent), rice (75 percent), and potato (20 percent). Whatever the source of starch, it has the same chemical composition, and is one of the group of substances known chemically as carbohydrates. Starch is extremely complicated in composition and, although the proportions in which carbon, hydrogen, and oxygen occur are known, the exact number of atoms making up the molecule is not known. Consequently, it is customary to give it the formula $(C_6H_{10}O_5)n$, the n and bracket indicating that this formula is only a simplified form and that the value of n is as yet unknown.

According to present theories, starch contains at least two carbohydrate substances. Both are polymers of glucose, but they differ markedly in properties and structure. One of these substances (called the A-Fraction in the case of corn starch), consists of a long chain-like molecule. This fraction is unstable in the colloidal sense and is responsible for the gelling and retrogradation of starch. It is characterized by the production of a blue color with iodine. The other component (designated as the B-Fraction), has a very large branched molecular structure and gives a reddish color with iodine. This fraction is

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[1] D. N. Jackman and G. R. Parker, The Chemistry of Laundering Materials, (Longman's and Greens Co. N. Y., 1931), 53-56.

colloidally stable and functions as a protective colloid for the A-Fraction.

Starches from various sources contain both A (gel) and B (sol) fractions in varying ratios. The differences in the properties of the pastes formed when these starches are boiled and in the stiffness, pliability, etc., which result when these pastes are allowed to dry, depend primarily on the ratio of A and B fractions in the molecules[1] and on the size and shape of the granules.[2] In a general way, starches derived from grain seeds yield pastes that are shorter and which gel or set back to a greater degree than those derived from tubers, such as potato and tapioca.

Rice Starch:

Rice is a cereal starch. Its properties are characterized by the fact that it has the smallest granule size of the common commercial starches.[3] It penetrates well and gives a hard finish with a fullness and firmness which is apt to be regarded as 'boardy.' It is of great interest in laundering as a stiffener, for it is affected less by humidity than are other starches.[4] It has not found wide industrial use because of its normal economic disadvantages and limited availability.

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[1] Textile World, "Chemistry of Starch Interests Finishing Man," 98 (May 1948), 174-180.

[2] A. Harrison, "Properties of starches Related to Stiffness," Journal of Society of Dyers and Colorists, 27 (1911), 86-87.

[3] A. Harvey, Laundering Chemistry, (The Technical Press Ltd. London, 1935), 78.

[4] D. N. Jackman and G. R. Parker, The Chemistry of Laundering Materials, (Longman's Green S. Co., N. Y. 1931), 53-56.

Corn Starch:

Corn starch exhibits the characteristic properties of cereal starches. It has the largest granule size of any starch and, because of the viscosity of its solution it gives a brittle and rigid film.[1] The feel imparted by this starch is not softened even by boiling the starch paste, but the soluble starches made from corn give better results.[2]

Therefore, the properties of corn starch have been varied widely through many chemical modifications of the starch polymer to meet special requirements.[3]

Liquid Starches:

The idea of making liquid starch has been given considerable attention during the past 10-15 years. A good liquid starch must possess some special properties in addition to those required by other starches.

Stability of suspension is one of the most important of these. An ideal liquid starch must not separate over a long period of time, even when subjected to high temperatures and exposure to light. Also, it must not support mold growth.[4]

One of the first patents covering a starch composition of this type was issued in 1941 (U.S. 2,228,736). It described a non-sticking and non-separating fiber penetrating liquid starch based on a chemical modification

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[1] Textile Colorists, "Starch and Starching," 60 (March 1944), 105-107.

[2] M. S. Furry, "Some Properties of Starch Paste Which Affect Their Stiffening Power on Fabrics," United States Department of Agriculture Technical Bulletin, (1929) No. 284.

[3] D. N. Jackman and G. R. Parker, The Chemistry of Laundering Materials, (The Longman's Green S. Co. N. Y. (1931), 53-56.

[4] Chemical Industries, "Liquid Starches," 61 (December 1947) 613.

of corn starch. This formula was rapidly imitated and soon a great number of liquid starches were available in the market.

Plastic Starches:

Although they produce a starch-like effect, these substances are not starches at all but synthetic plastics. The two common products are Perma starch and Plasta starch. Perma starch contains an emulsion type vinyl resin, while Plasta starch is a mixture of Polyvinyl acetate, tricresyl phosphate, and water.[1] Both of them are liquid and could be used just as any other liquid starch by diluting in water. Ironing of the fabric causes further polymerization to form water insoluble plastics.

Unlike conventional starches which coat the fabric, small particles of plastic starches penetrate between the cotton fibers in the yarn.[2]

The claims are also made that these starches double the life of cotton garments. The chief appeal of the plastic starches is that, since they do not wash out as readily, they need not be applied as often as common starches. This factor also helps to lessen the cost differential between the plastic starches and the ordinary starches.

Sodium Carboxy Methyl Cellulose:

Another substance sometimes used for starching is sodium carboxymethyl cellulose or CMC as it is often called. The liquid CMC is faintly yellow so that for commercial use it is mixed with a blueing agent. It has a medium viscosity and has high penetrating power. The stiffness

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[1] Consumer Report, "Plastic Starches," 14 (June 1949), 271-272.

[2] Consumer Research Bulletin, "Plastic Starches," 29 (June 1952), 19.

produced in a fabric is even greater than that produced by the same amount of a plastic starch. Since a more common use for carboxymethyl cellulose is as a soil suspending agent in synthetic detergents, it has been postulated that the use of CMC as a starch might also assist in soil removal.[1]

Laboratory Testing Methods

Fabric drapeability is the primary physical quality which is affected by starching. This quality of a fabric is now expressed by the subjective judgement of an expert, who on feeling, bending, and crushing a fabric in his hands, describes it as soft, harsh, boardly, lofty, or in some other terms. This judgement means little to a non-expert and does not facilitate accurate comparisons with other fabrics, nor the comparison of the feel of the same fabric to other experts.

Drapeability is a very complex mixture of properties, in which the main, but certainly not the only, factor involved is stiffness. Many laboratory testing methods have been devised for testing this property in an effort to obtain tests that will give a valid indication of how the fabric will behave in actual use. In most cases, present laboratory tests do not attain this goal, but nevertheless, they do give us some valuable data.[2]

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[1]M. A. Grime and C. A. Werman. "Effectiveness and Serviceability of four Home Applied Cotton Finishes," Texas Agricultural Experiment Station Bulletin, (1957), No. 853.

[2]J. H. Skinkle, Textile Testing, (Chemical Publishing Co., Brooklyn, N. Y., 1949), 121-135.

Measurement of Stiffness

Cantilever Method:

Pierce stated that the stiffness of a fabric depends largely on its resistance to bending and on its weight. The most important of the measurements he described is the determination of the ratio of these two factors expressed in suitable units. This ratio (flexural rigidity), he regarded as a quantitative measure of stiffness.[1]

The cantilever method for measuring stiffness was first described by Pierce[2] and was later modified by Peterson, and Dantizig.[3] This method is now accepted as the preferred method for measuring the stiffness of woven fabrics by the American Society for Testing Materials, and by the Administrative Committee on Standards.[4]

In this method, a strip of fabric is slid in a direction parallel to its long dimensions, so that its end projects from the edge of a horizontal surface. The length of overhang is measured when the tip of the specimen, under its own weight, bends through a 41.5° angle. One-half of this length is the bending length of the specimen. The cube of the bending length multiplied by the weight per unit area (in grams per

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[1] F. T. Pierce, "The Handle of Cloth as a Measurable Quantity," Journal of the Textile Institute, 21 (1930), T 377.

[2] Ibid. p. T 377.

[3] E. C. Peterson and T. Dentizig, "Stiffness in Fabrics Produced by Different Starches and Starch Mixtures and a Quantitative Method for Evaluating Stiffness," United States Department of Agriculture Technical Bulletin, (1939), No. 108.

[4] A. S. T. M. (Committee D-3) Standards for Textile Materials, (Published by American Society for Testing Materials Philadelphia, Pennsylvania, 1959), 591-596.

square centimeter) of the fabric is the flexural rigidity or stiffness of the fabric.

For fabrics too stiff for the standard method, a known weight is fixed to the end of the fabric.[1]

Heart Loop Method:

Pierce also suggested a method called the heart loop method for use with very soft materials where the stiffness can not be accurately measured by the previous method. A 1 x 6 inch strip of the fabric is folded back on itself and clamped, so that it hangs in a heart shaped loop. If the length of this loop is measured, the stiffness is inversely proportional to this length. From the length of heart loop, the bending length and flexural rigidity may be calculated as in the cantilever method.[2]

Both of these methods are applicable to fabrics of any fiber content, but the cantilever method is preferred by the American Society for testing materials,[3] because it is simpler to carry out. However, it is not suitable for testing very limp fabrics or fabrics which have a tendency to curl or twist at the cut edge. In these cases the heart loop test is preferred.[4]

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[1]F. T. Pierce "The Handle of Cloth as a Measurable Quantity," Journal of the Textile Institute, 21 (1930), T 377.

[2]E. R. Kaswell, Textile Fiber, Yarn and Fabrics, (Reinhold Publishing Corporation, N. Y., 1953), 421-462.

[3]A. S. T. M. (Committee D-3) Standards for Textile Materials, (Published by American Society for Testing Materials, Philadelphia, Pennsylvania, 1959), 591-596.

[4]Ibid. "Comparison of Certain Methods of Measuring Stiffness in Fabrics," American Dyestuff Reporter, 26 (1937), 667; 28 (1939), 688; 29 (1940), 400, 689.

The two methods may not give the same numerical value, but both have given excellent correlations with a subjective evaluation obtained by feeling the fabric.[1]

Planoflex:

This device described by Derby measures the angle through which a fabric may be distorted in its own plane without producing wrinkles in the fabric.[2]

The planoflex has a movable clamp, a fixed clamp and a hinged shelf. The movable clamp is attached to the fixed clamp by two strips so that it is able to move in an arc having a radius of six inches which is always parallel to the fixed clamp. One end of the sample is fastened in the movable clamp which is at zero and a two pound clamp which rests on the hinged shelf is attached to the other end of the sample. The hinged shelf is then released so that the sample is under tension. The movable clamp is moved slowly until wrinkles appear in the sample. The sum of the left and right angles is recorded.[3]

Drapemeter:

This instrument measures a combination of stiffness and other draping qualities.[4] The apparatus consists of a semicircular disc to

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[1]A. S. T. M. (Committee D-3) Standards for Textile Materials, (Published by American Society for Testing Materials, Philadelphia, Pennsylvania, 1959), 591-596.

[2]E. C. Derby, "The Planoflex," American Dyestuff Reporter, 3 (1941), 651.

[3]J. H. Skinkle, Textile Testing, (Chemical Publishing Co. Brooklyn, N. Y.), 121-135.

[4]E. R. Kaswell, Textile Fiber, Yarn and Fabrics, (Reinhold Publishing Corporation, N. Y., 1953), 421-462.

which the specimen is attached and from which it hangs. With this apparatus, the cloth arc can be traced at different levels. An infinitely soft fabric would have a semicircular outline at all levels, whereas an infinitely stiff but elastic fabric would vary from a semicircle at the top to a straight line at the bottom. However, most commercial fabrics would fall between these two extremes.[1]

Measurement of Crease Recovery

The application of starch to a fabric results in a change in fabric properties other than stiffness, e.g., crease resistance and crease recovery. Many methods for measuring crease recovery have been described by Buck and McCord,[2] and others, but the Monsanto crease recovery test has been most widely accepted.[3]

Monsanto Method:

This method was developed by the Shirley Institute and further refined by the Textile Resin Department of the Monsanto Chemical Company. In this method one end of the creased sample is held in a jaw while the other hangs free and is brought into coincidence with a vertical line of the tester. The angle which the free end makes with the

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[1] J. H. Skinkle, Textile Testing, (Chemical Publishing Co., Brooklyn, N. Y., 1949), 121-135.

[2] G. S. Buck and F. A. McCord, "Crease Resistance and Cotton," Textile Research Journal, 19 1949), 261, 267.

[3] A. S. T. M. (Committee D-3) Standards for Textile Materials, (Published by American Society for Testing Materials, Philadelphia, Pennsylvanis, 1959), 526 - 528.

clamped end after a specified time of suspension on the tester is a measure of crease recovery of the fabric.[1]

The influences of fabric weight and stiffness are largely eliminated by holding one end of the cutting in the clamp and arranging the other end in vertical suspension.[2] Kaswell also stated that the Monsanto method is simple to operate and well designed. It is small and portable, and gives adequate results for most developmental or merchandising purposes.[3]

Summary of Review of Literature

The use of starch has been known from time immemorial and according to dePierre (Traite des Apprets, Paris, 1887, F 14) it was even used as a textile finish in 800 B.C.[4] The early use of starch in textile industry was as a sizing in weaving. At present it is used commerically as well as in the home to give body, crispness, and smoothness to cotton fabrics and garments. Jackman and Parker also mentioned that starched fabrics were less liable to retain dirt and consequently tend to keep clean for longer periods of time than do the unstarched materials.[5]

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[1] A. S. T. M. (Committee D-3), Standards for Textile Materials, (Published by American Society for Testing Materials, Philadelphia, Pennsylvania, 1959), 526-528.

[2] Ibid., p. 526-528.

[3] E. R. Kaswell, Textile Fiber Yarn and Fabrics, Reinhold Publishing Corporation, N. Y., 1953), 177, 256-297.

[4] Textile Colorists, "Starch and Starching," 60 (March 1944), 105-107.

[5] D. N. Jackman and G. R. Parker, The Chemistry of Laundering Materials, (Longman's and Greens Co. N. Y., 1931), 53-56.

Starch is extremely complicated in composition and belongs to carbohydrate group of chemical substances. It is usually given a formula $(C_6H_{10}O_5)n$, the n and the bracket indicating that the formula is only a simplified form and that the value of n is as yet unknown. Starch is made of two fractions. One of them (called the A-Fraction) consists of long chain like molecules. This is unstable in the colloidal sense. The other fraction (designated as the B-Fraction), has very large branched molecular structure. This fraction is colloidally stable and functions as a protective colloidal for the A-fraction. Different types of natural and modified starches from various sources contain both A and B fractions in varying ratios. The difference in properties of these starches depend primarily on the ratio of A and B fractions present in the molecules[1] and on the size and shape of the granules. Some other substances which are used as starches are polyvinyl synthetic starches and Sodium carboxyl methyl cellulose. These substances are not starches at all, but belong to different classes of chemical compounds.

Laboratory Testing Methods

Fabric drapeability is the primary physical quality which is affected by starching. Drapeability is a very complex mixture of properties, in which main but certainly not the only, factor involved is stiffness.[2] The application of starch to a fabric also results in a change in fabric properties other than stiffness, that is, crease

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[1] Textile World, "Chemistry of Starch Interests Finishing Man," 98 (May 1948), 174-180.

[2] J. H. Skinkle, Textile Testing, (Chemical Publishing Co., Brooklyn, N. Y., 1949), 121-135.

resistance and crease recovery. Many methods of measuring stiffness and crease recovery have been developed.

Cantilever is the preferred method for measuring stiffness of woven fabric. It is easy to operate and does not take long time.[1] Heart loop is a suitable method for measuring stiffness of very limp materials or those which have a tendency to curl or bend.[2] Planoflex and drapemeter are two methods which measure the combination of stiffness and draping qualities.[3] Monsanto method of measuring crease recovery is the best and most widely accepted out of many that have been described by Buck and McCord and others.[4]

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[1]A. S. T. M. (Committee D-3) Standards for textile Materials, (Published by American Society for Testing Materials, Philadelphia, Pennsylvania, 1959), 591-596.

[2]Ibid., p. 591-596.

[3]E. R. Kaswell, Textile Fiber Yarn and Fabrics, (Reinhold Publishing Corporation, N. Y., 1953), 256-297.

[4]A. S. T. M. op. cit., p. 591-596.

CHAPTER III

METHODS OF PROCEDURE

The work in this study was divided into two phases: 1. The preparation of the fabric. This included the selection of fabric and starches, the selection of suitable concentration of each starch and actual starching of the samples. 2. The laboratory testing of the effect of the starches on fabric stiffness and crease resistance as compared to those of the unstarched fabric.

Preparation of Fabric

Selection of Fabric

The selection of the fabric used in this study was an important factor in order to show the effect of various types of starches. A light weight plain woven fabric without a crease resistant finish was most desirable, because cotton saris are made of a similar fabric. It was also desirable for the fabric to be a plain dark color, so that sticking or spotting of the starches, if any, would be clearly visible. The fabric chosen was a black non-crease resistant cotton batiste. This fabric contained very little sizing material which was removed by washing in an automatic washing machine.

Selection of Starches

Selection of starches was very important, for the 'hand' given by using the same amounts of different types of starches is not the same.

Six starches were used during this study. They represented almost all of the different types of materials that are used for starching in United States and in Pakistan.

Rice was chosen because it is commonly used by the women of Pakistan for starching their cotton saris. The rice was used in the grain form and the paste was obtained by boiling the grains in water. This method of preparing starch is used in Pakistan. Corn starch represented the commonly used starch in United States and it was used as boiled starch. Out of the two chemically treated corn starches that were selected, one was a modified cold water soluble starch and the other a modified liquid starch. The fifth product was based upon carboxymethyl cellulose (CMC) as the stiffening ingredient. It will be referred as CMC starch in further discussions. The sixth starch belonged to the synthetic starch classification which contained polyvinyl acetate as basic material.

All the starch mixtures except rice were prepared according to the directions given on the labels. The amount of various materials necessary to give a medium concentration ranged from 1/2 tablespoon for corn starch to 1 - 1/2 cup for CMC. The rice starch was prepared by the following procedure:

> Four tablespoons of rice were cooked below the boiling point in two cups of water for 40 minutes. The mixture was separated through a sieve without rubbing the rice. One-half cup of liquid was obtained from this process. This, plus 2 cups of water was used as the medium concentration of rice starch.

Starching of Pilot Samples

To select the proper concentration of each starch, first a pilot starching of 9 x 9 inch samples was done. Five concentrations ranging from that recommended by the manufacturer for medium stiffness to one-fourth of the recommended light starch concentration were tried. Each starch was diluted with water according to the proportions given in Table I (p. 38). The samples were starched, dried in the air, and pressed with a steam iron set for the cotton.

Since there was no objective method for measuring the stiffness necessary for a cotton sari, a panel of five members was asked to personally select the best concentration for each of the six starches. All five of the members of the panel were Pakistani or Indian women who had draped and worn a cotton sari before.

The selection was greatly affected by the woman's height and weight and personal choice. Tall and slender members selected the stiffest samples. One member of average size selected the least stiff sample and the other of the same size the most stiff sample on the basis of personal choice. Thus, the results of the panel selection were conflicting showing little or no agreement.

Starching of Actual Samples

Eighteen samples, 18 x 36 inches were cut from the cotton batiste and starched in three concentrations, (medium, light, and one-fourth of light) of each starch. The starch mixtures were prepared according to the directions given by the manufacturers. The actual proportions of water and starches used for these starchings are given in Table II (p. 39).

The starched samples were dried in the air and pressed with a steam iron at the cotton setting.

Laboratory Testing

Selection of Testing Methods

Four methods were selected for measuring stiffness. Cantilever is the preferred method for measuring stiffness of woven fabrics by the American Society for Testing materials, and by the Administrative Committee on Standards.[1] Heart loop is a suitable method for measuring stiffness of very limp materials or those which have a tendency to curl or bend. The other two methods were modifications of planoflex and drapemeter. They are the instruments for measuring the combination of stiffness and other draping qualities.

Angle of crease recovery was measured by Monsanto method. In this method influence of fabric weight and stiffness on angle of crease recovery are largely eliminated and the results are adequate for most developmental purposes.[2]

Preparation of Test Specimens

The following specimens for testing stiffness and crease recovery were cut from each of the 18 starched samples and one unstarched sample according to the cutting diagrams given in Figure 1, p. 42.

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[1]A. S. T. M. (Committee D-3), Standard for Textile Materials, (Published by American Society for Testing Materials, Philadelphia, Pennsylvania, 1959), 591-596.

[2]E. R. Kaswell, Textile Fiber, Yarns and Fabrics, (Reinhold Publishing Corporation, N. Y., 1953), 421-426.

Test	Number of Specimens Filling	Warp	Measurement
Cantilever	5	5	6 x 1 inch
Heart loop	5	5	6 x 1 "
Drapemeter	2	1	10 x 5 "
Angle of creasing	3	2	10 x 3 "
Crease Recovery	5	5	4 x 1 - 1/2 c.m.

All fabric specimens were conditioned at the standard conditions of 70° F. and 65 percent relative humidity for 24 hours before testing for stiffness and crease recovery. As both stiffness and crease recovery can be greatly affected by the Prescence moisture, care was taken to avoid transfer of moisture from the fingers to the region of the specimen to be tested.

Measurement of Stiffness

Cantilever. The tester was placed on a horizontal platform at eye level. Five warp and five filling specimens, 1 x 6 inches, from each of the nineteen samples were tested by placing each on the platform with weight on top. The weight and the specimen were moved slowly forward until the projecting edge of the specimen fell to the level of the inclined plane. The length of overhang was recorded. Four such readings were recorded for each specimen. These were averaged and then divided by two to give the average bending length. Since the weights of these samples were essentially the same, flexural rigidities were not calculated.

Heart loop. Five warp and five filling specimens, 1 x 6 inches, from each of the nineteen samples were tested. Each strip was folded back on itself and clamped so that it hung vertically in a heart shaped loop under its own weight. The length of this loop was measured in centimeters after one minute. Two such readings were obtained from each side of the specimen. The average length of the heart loop was calculated for each sample.

Angle of Creasing. To measure angle of creasing, three filling and two warp specimens were cut from each of the nineteen fabric samples. Each specimen was clamped on a clipboard in such a way that the free end touched the zero mark of the scale drawn on the other end. The free end was then moved slowly until a wrinkle appeared in the specimen. The angle through which the specimen was rotated was read from the scale. Such a test would roughly correspond to a planoflex test. Two such readings were taken from each side of the specimen and the average for each sample was calculated.

Drapemeter. Two filling and one warp specimen, 5 x 10 inches, were cut from each of the nineteen fabrics. Each specimen was tested on an improvised drapemeter by hanging from a semicircular disc, 4 inches in diameter, which was supported by a clamp over a mirror. The inside chord length of the lower edge of the specimen, as seen in the mirror was read using a centimeter scale. Two such readings one for each side of the specimen were made. These were then averaged.

Measurement of Crease Recovery

The Monsanto method for measuring crease recovery was used in this study. Five warp and five filling specimens, 1 - 1/2 x 4 centimeters, were cut from each of the nineteen fabric samples. After being creased under a 500 gram weight for five minutes, one end of the creased cutting was held firmly in the clamp while the other hung free and was brought into coincidence with a vertical line on the tester. The angle which the free end made with the clamped end after a five minute suspension was recorded as the crease recovery angle. The average crease recovery angle was calculated for both the warp and filling directions of each of the nineteen samples.

CHAPTER IV

DISCUSSION OF RESULTS

A comparison of the samples starched in three concentrations of six types of starches was made on the basis of spotting, stiffness and crease recovery. The three solid starches caused spotting, this was especially obvious in the case of rice starch. The stiffness and crease recovery were compared to that of an unstarched sample. The stiffness imparted to the fabric samples was directly proportional to the starch concentrations. The stiffest fabric was obtained from the medium concentration of liquid corn starch. The low concentrations of all starches produced practically no increase in stiffness since the bending lengths of the starched samples were about the same as those of unstarched sample.

In general, the crease resistance was inversely proportional to the starch concentration. That is, crease resistance was lowered as the starch concentration was increased for all starches except CMC and cold-water soluble starch where the reverse was true.

Effect of Starching

White Spotting

The liquid starches, that is, liquid corn starch, CMC and synthetic starch, gave better penetration of the fabric than the solid starches because of their lower viscosity and left no mark on any of the samples at any concentration. However, spotting was caused by all three solid starches, that is, coldwater soluble starch, corn starch and rice starch, at all concentrations. In the case of coldwater soluble starch and corn starch there were several white spots, but rice coated the fabric more completely. This coating was not continuous, but it was very obvious on the fabric starched at the medium rice starch concentration.

Stiffness

The stiffness produced by the six starches was compared with that of an unstarched sample. In general, the stiffness was directly proportional to starch concentration, that is, stiffness was decreased as the concentration was lowered.

The stiffness was measured by four methods: Cantilever, Heart loop, Angle of creasing, and Drapemeter. The averages of the results obtained using these methods are given in Tables III (p. 40) and IV (p. 41).

Cantilever. The cantilever method measured the bending length in centimeters. The values obtained were proportional to the starch concentration for all of the starches. The higher concentrations gave longer bending lengths and the bending lengths decreased as the concentrations were lowered. The range between the bending lengths of most stiff and least stiff samples was 1.4 centimeters.

The difference in the bending lengths produced by the medium concentrations of the six starches was 1.2 centimeters. Also, all of the filling samples had slightly higher bending lengths than the corresponding warp samples, and will be used in the further discussion of results. The most stiff sample was produced by liquid corn starch (bending length 2.8 centimeters) while the one starched with CMC was the least stiff (1.7 centimeters). Rice was next to liquid corn starch in stiffening power (2.7 centimeters). The stiffness given by coldwater soluble starch and corn starch was the same (2.4 centimeters), while that given by synthetic starch was 2.2 centimeters.

All the samples starched in one-fourth of the light concentrations were very limp. The filling bending lengths of the samples treated with synthetic starch, CMC and coldwater soluble were the same as that of original sample (1.5 centimeters). Corn starch and rice starch were next (1.7 centimeters) while liquid corn starch was most stiff (1.8 centimeters).

Contrary to the opinion expressed by Grimes and Werman[1] that carboxymethyl cellulose produced more stiffness than the other starches used in their study, it was found during this work that samples treated with CMC were the least stiff. Likewise synthetic starch, which has been claimed to produce stiffer fabrics,[2] gave samples next to CMC in limpness. In both of these cases, this reversal of effect may have been due to the use of lower concentrations than was used in the previous work.

Heart loop. In the heart loop method the length of the loop measured corresponded to the bending length of the cantilever method. However, in this case the loop length was smaller for the stiffer samples and longer for the limp ones. Again, the results showed good correlation with the three starch concentrations of each starch (Tables III, p. 40, and IV, p. 41). That is, the loop lengths always increased as the concentration of each starch was lowered. In general the increase in stiff-

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[1]M. A. Grime and C. A. Werman, "Effectiveness and Serviceability of four Home applied Finishes," Texas Agricultural Experiment Station Bulletin, (1957), No. 853.

[2]Consumer Report, "Plastic Starches," 14 (June, 1949), 271-272.

ness over the unstarched sample was greater in the filling direction than in warp.

The filling loop lengths for the samples starched in the medium concentrations ranged from 3.3 to 2.6 centimeters. Rice caused most stiffening while synthetic starch and CMC gave limpest samples. Liquid corn starch and coldwater soluble starch gave samples that were nearly as stiff as those treated with rice starch. While the samples treated with corn starch were almost as limp as those treated with CMC.

When the concentration was lowered to one-fourth of the light, the ranking of the starches was changed slightly. Rice which gave the stiffest sample at the higher concentration, was slightly less stiff than CMC. Liquid corn starch and coldwater soluble starch were the lowest.

<u>Angle of Creasing</u>. The angle of creasing tended to increase slightly as the starch concentrations were lowered (Tables III, p. 40 and IV, p. 41). However, this method did not seem to be as sensitive as the first two used.

The values for the angle of creasing in the filling direction ranged from 2.3-4.0° for the medium concentrations of all starches. Rice caused greatest and synthetic starch the least stiffening. Corn starch was next in stiffness (3.0°) while CMC, liquid corn starch and coldwater soluble starch had the same angle of creasing, (3.7°).

The synthetic starched sample was rated most limp at the one-fourth of the light concentration. It had an angle of 6.0° as compared to 6.7° for the original fabric. Liquid corn starch was next in limpness (5.7°). CMC and coldwater soluble starch had the same angles (5.0°) and rice and corn starch were next (6.3^{o} and 3.0^{o}).

Drapemeter. There seemed to be poor correlation between the measured chord lengths and the starch concentrations with which the samples were treated (Tables III, p. 40 and IV, p. 41). The chord length did decrease as the concentration was lowered except in the case of synthetic starch (Filling) and synthetic starch and rice (warp).

Crease Recovery

In general, there was quite good correlation between the angles of crease recovery and stiffness of the samples (Figures 8 and 9, pp. 49 and 50). The crease resistance was less for the higher concentrations of all starches, except CMC and coldwater soluble starch, where the opposite was true. The decrease in crease recovery was greatest in the filling direction where the stiffening effect of the starches was greater.

The CMC sample had the highest filling crease recovery (89^{o}) at medium concentration, while the rice sample had the lowest (65^{o}) in the filling. The coldwater soluble starch, corn starch, liquid corn starch and synthetic starch samples followed CMC in crease recovery with angles of 86^{o}, 72^{o}, 69^{o}, and 67^{o}.

Even the one-fourth of the light concentration considerably lowered the crease recovery of all samples. CMC with the highest crease recovery at this concentration, 79^{o}, was 15^{o} less than that of the original sample, 95^{o}.

Comparison of Methods of Stiffness Measurement

The cantilever method gave the best results in this study since the bending lengths obtained by this method were proportioned to the three concentrations for all starches. It seemed to be slightly more sensitive to the differences caused by the starches than was the heart loop method. In addition, the apparatus was easy to operate, took the least time, and it was easy to avoid handling the specimens with fingers.

The heart loop method was next to cantilever in the accuracy and sensitivity of the results. There was an inverse correlation between starch concentration and sample loop length. However, the difference between the warp and filling measurements or between starches were not as pronounced as they were in the case of cantilever test. There was a close relationship between the results of the cantilever and heart loop methods as can be seen in the scatter diagrams plotted in Figures 2 and 3, pp. 43 & 44. It was not very easy to do this test and the handling of the samples with the fingers was difficult to avoid.

The method for measuring the angle of creasing was not as satisfactory as the above two methods. This test was not very sensitive to differences in stiffness caused by varying the starch concentrations. Neither did it show the difference between the warp and filling stiffness shown by the first two methods. The correlation with the results of the cantilever was much poorer than that obtained by the heart loop method (Figures 4 and 5, pp. 45 & 46). Again, the apparatus was not easy to operate and handling of specimens with fingers could not be avoided. This may partially account for the poor results and for the poor correlation with the other methods.

The drapemeter method was the least sensitive and the least reliable. The chord lengths measured by this method did not vary greatly as the concentration was varied.

Likewise, the chord lengths measured with this method showed no correlation with the bending lengths measured by the cantilever method (Figures 6 and 7, p. 47 and p. 48).

CHAPTER V

SUMMARY

In Pakistan cotton saris are very popular. The cotton fabric, though it may look very beautiful and elegant, also creates some problems for the wearer. As the sari is an untailored dress, part of its beauty depends upon the draping qualities of the fabric. The softer the fabric, the better it will drape, yet the cotton fabrics used in saris must be starched in order to give them adequate body and smoothness. Therefore, the objectives of this study were: 1. To compare the effect of different types of natural, modified and synthetic starches on the stiffness and crease recovery of a cotton fabric, 2. To compare and evaluate the methods for measuring stiffness, 3. To compare the effect of starches on crease recovery.

Six starches, corn, CMC, coldwater soluble, synthetic starch, rice, and liquid corn starch, were tried on a black cotton batiste. Three concentrations, medium, light, and one-fourth of the light were selected. Starch mixtures were made according to the directions given on the label for each starch except rice, which was prepared according to the method used by the Pakistani women.

The 18 samples obtained by starching the cotton fabric in the above starch mixtures were compared with the original fabric for spotting, stiffness, and crease recovery.

1. White spotting was observed in all of the samples treated with solid starches, that is, corn starch, coldwater soluble starch, and rice. This spotting was most obvious in the sample starched with rice.

2. Stiffness was directly proportional to the starch concentrations. Liquid corn starch and rice gave the stiffest samples while CMC gave the limpest samples.

3. Crease recovery was inversely proportional to starch concentrations for all starches except CMC and coldwater soluble starch. In these two cases the crease recovery was higher for the higher concentrations.

Four methods, cantilever, heart loop, angle of creasing and drapemeter were used to measure the effect of starches on the stiffness of this cotton fabric.

The results obtained by the cantilever and heart loop methods seemed to be the most sensitive and accurate of the four methods. Of these two, the cantilever was easiest to perform. The angle of creasing and drapemeter methods did not give satisfactory results.

Recommendation for Future Research and Teaching

The results obtained from this study could be utilized by the author for future research in college of Home Economics, Karachi, Pakistan. The cotton saris starched in different concentrations of natural and synthetic starches may be used. These saris may be given to college students and/or staff members to be worn for certain periods of time and may be evaluated by a panel as to the stiffness, wrinkling and general appearance. Objective tests in the textile laboratory could be made before and after several washings and the comparative effects of starches could be determined.

The information from this study may be used to encourage the industries to manufacture less expensive synthetic starches. Even if synthetic starches remain comparatively more expensive than the natural rice and wheat starches, they would be economical in the long run as their effect is more lasting and can stand several washings.

One of the main responsibility of the author in the college of Home Economics would be to teach textile in the department of clothing and textile. The understanding gained about the mechanism and properties of starches will enable her better to explain it to her students. The knowledge of effect of various starches would help her in suggesting a better method for starching and laundering the much used cotton saris.

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APPENDIX

TABLE I

Starch Concentrations used for Starching of Pilot Samples

	Starches	Amount				
		Medium	1/2 Medium	Light	1/2 Light	1/4 Light
1.	Rice*	1/2c+2c H_2O	1c of 1 + 1 c H_2O	1c of 2+ 1c H_2O	1c of 3 + 1 c H_2O	1c of 4 + 1 c H_2O
2.	Corn starch	1/2T+2 c H_2O	1c of 1 + 1c H_2O	1c of 2+1c H_2O	1c of 3 + 1c H_2O	1c of 4 + 1c H_2O
3.	Coldwater soluble starch	2T+2c H_2O	1T+2c H_2O	1/2T+ 2c H_2O	1/4T+2c H_2O	1/8T+2c H_2O
4.	Liquid corn starch	1+1/3c +2 c H_2O	1c of 1 + 1c H_2O	1c of 1+1c H_2O	1c of 3 + 1c H_2O	1c of 4 + 1c H_2O
5.	CMC	1-1/2c + 2c H_2O	1c of 1 + 1 c H_2O	1/3 c+ 2 c H_2O	1c of 3 + 1c H_2O	1c of 4 + 1c H_2O
6.	Synthetic starch	6T +2c H_2O	1c of 1 + 1 c H_2O	1c of 2+ 1c H_2O	1c of 3 + 1c H_2O	1c of 4 + 1c H_2O

* Four Tablespoons of rice were cooked below boiling point in two cups of water for 40 minutes. The mixture was separated through a sieve without rubbing the rice. The liquid so obtained was half cup. This + 2 cups of water gave us the medium rice starch.

TABLE II

Starch Concentrations Used for Starching of Fabric

	Starches	Amount		
		Medium	Light	1/4 Light
1.	Rice	1/2c + 1 c H_2O	1c of 1 + 1c H_2O	1c of 2 + 1c H_2O
2.	Corn starch	1/2T + 2c H_2O	1c of 1 + 1 c H_2O	1c of 2 + 1c H_2O
3.	Coldwater soluble starch	2 T + 2c H_2O	1/2T + 2c H_2O	1/8 T + 2 c H_2O
4.	Liquid corn starch	1 + 1/3 c + 2c H_2O	1c of 1 + 1c H_2O	1c of 2 + 1c H_2O
5.	CMC	1-1/2 c + 2c H_2O	1c of 1 + 1 c H_2O	1c of 2 + 1c H_2O
6.	Synthetic starch	6T + 2c H_2O	1c of 1 + 1 c H_2O	1c of 2 + 1c H_2O

TABLE III

Filling Stiffness and Crease Recovery of a Cotton Batiste

Treated with Six Starches

Test Methods

Starches	Cantilever Bending Length in cm.	Heart Loop Loop Length in cm.	Angle of Creasing	Drapemeter Chord Length in cm.	Angle of Crease Recovery
Unstarched	1.5	4.3	6.7	9.2	95°
1. Rice					
Medium	2.7	2.6	2.3	10.2	65°
Light	2.1	3.5	3.7	10.1	73°
1/4 Light	1.7	3.9	4.3	10.3	77°
2. Corn starch					
Medium	2.4	3.2	3.0	9.4	72°
Light	1.9	3.7	3.3	9.3	76°
1/4 Light	1.7	4.0	3.0	9.6	75°
3. Coldwater soluble starch					
Medium	2.4	2.9	3.7	10.4	84°
Light	2.1	3.3	4.0	10.2	75°
1/4 Light	1.5	3.8	5.0	9.8	70°
4. Liquid corn starch					
Medium	2.8	2.8	3.7	9.9	67°
Light	2.3	3.4	4.0	9.9	73°
1/4 Light	1.8	3.8	5.7	9.7	75°
5. CMC					
Medium	1.7	3.3	3.7	9.7	86°
Light	1.6	3.5	5.0	10.4	71°
1/4 Light	1.5	3.8	5.0	9.2	69°
6. Synthetic starch					
Medium	2.2	3.3	4.0	10.8	69°
Light	1.8	3.8	5.3	10.5	77°
1/4 Light	1.5	4.1	6.0	10.4	79°

TABLE IV

Warp Stiffness and Crease Recovery of a Cotton Batiste

Treated with Six Starches

Test Methods

Starches	Cantilever Bending Length in cm.	Heart Loop Loop Length in cm.	Angle of Creasing	Drapemeter Chord Length in cm.	Angle of Crease Recovery
Unstarched	1.5	4.4	6.0	9.1	90°
1. Rice					
Medium	2.1	2.8	2.5	10.3	78°
Light	1.9	3.4	3.0	10.2	85°
1/4 Light	1.5	3.7	4.5	9.2	96°
2. Corn starch					
Medium	1.8	3.6	2	9.7	82°
Light	1.8	3.8	3.5	10.3	86°
1/4 Light	1.6	4.1	3.5	9.8	88°
3. Coldwater soluble starch					
Medium	2.3	2.9	3.0	10.2	84°
Light	2.2	3.0	3.5	10.6	84°
1/4 Light	1.5	4.1	4.0	9.0	75°
4. Liquid corn starch					
Medium	2.7	2.7	3.0	10.0	83°
Light	2.3	3.1	4.0	9.6	85°
1/4 Light	1.6	3.8	4.5	9.5	88°
5. CMC					
Medium	1.6	3.4	4	9.5	89°
Light	1.5	3.7	4	10	80°
1/4 Light	1.4	4.1	5	9.5	79°
6. Synthetic starch					
Medium	2.1	3.2	3	10.1	83°
Light	1.7	3.9	4	10.1	89°
1/4 Light	1.5	4.2	4	9.7	86°

A = Angle of Creasing = 3 x 10"
C = Cantilever-------- = 1 x 6"
c = Crease Recovery-- = 1-1/2 x 4 c.m.
D = Drapemeter-------- = 5 x 10"
H = Heart Loop-------- = 1 x 6"

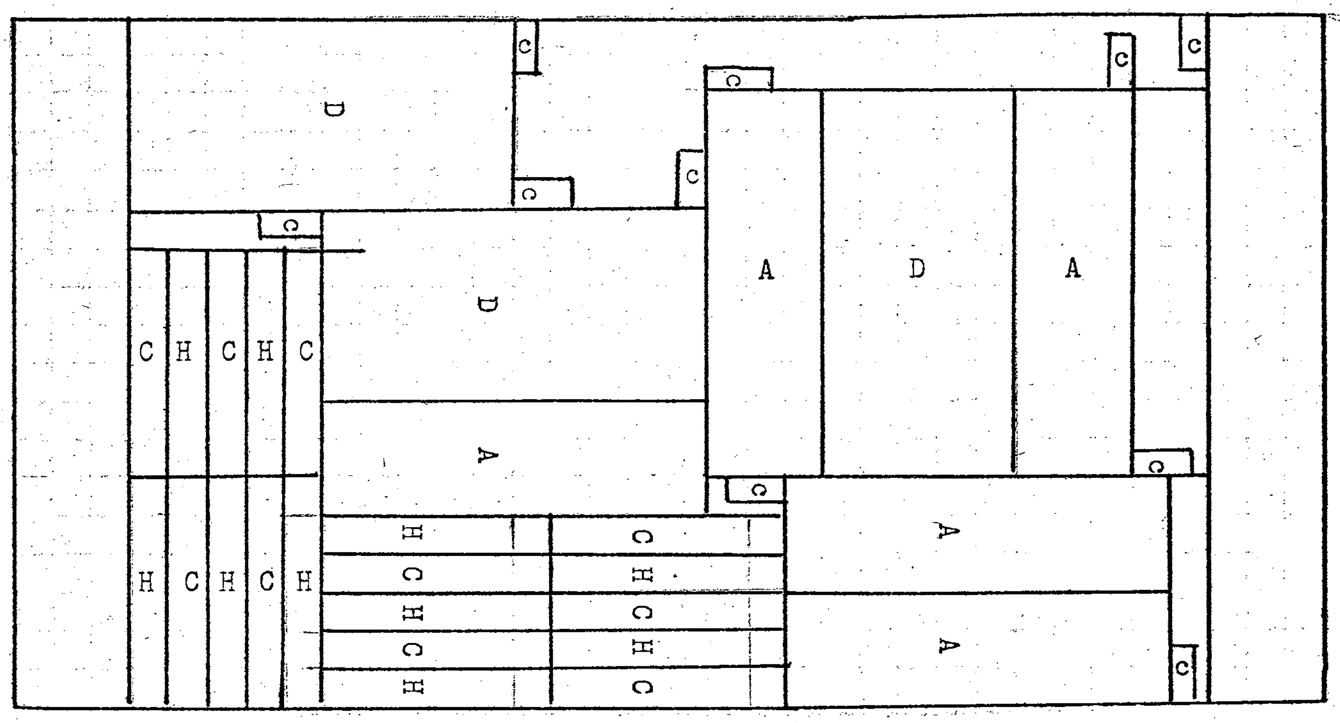

Figure 1. Cutting Plan-Fabric Sample Marked with Test Specimens
(3/16" = 1 inch)

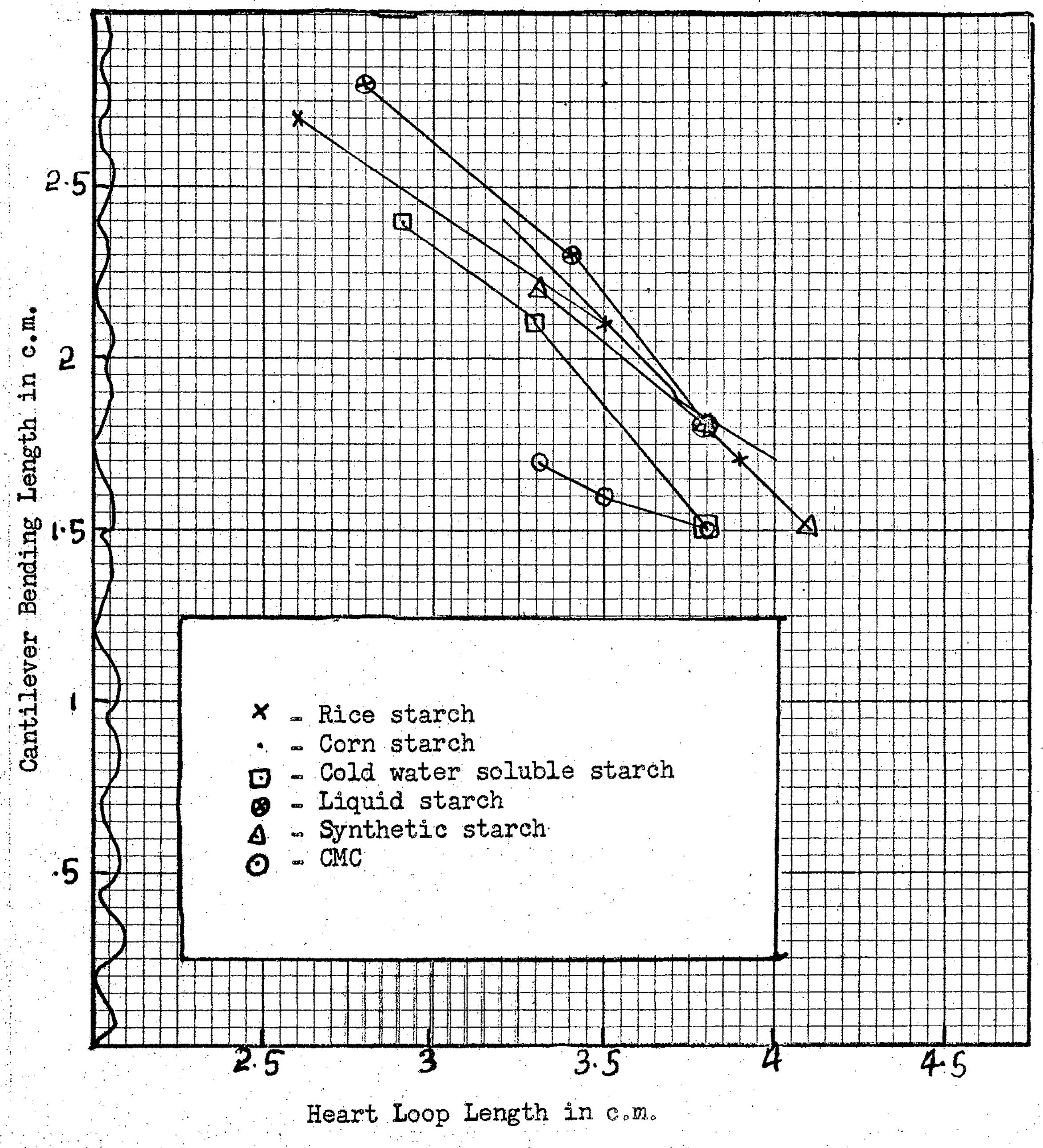

Figure 2. The Relationship Between Cantilever and Heart Loop Methods for Measuring Stiffness in the Filling Direction

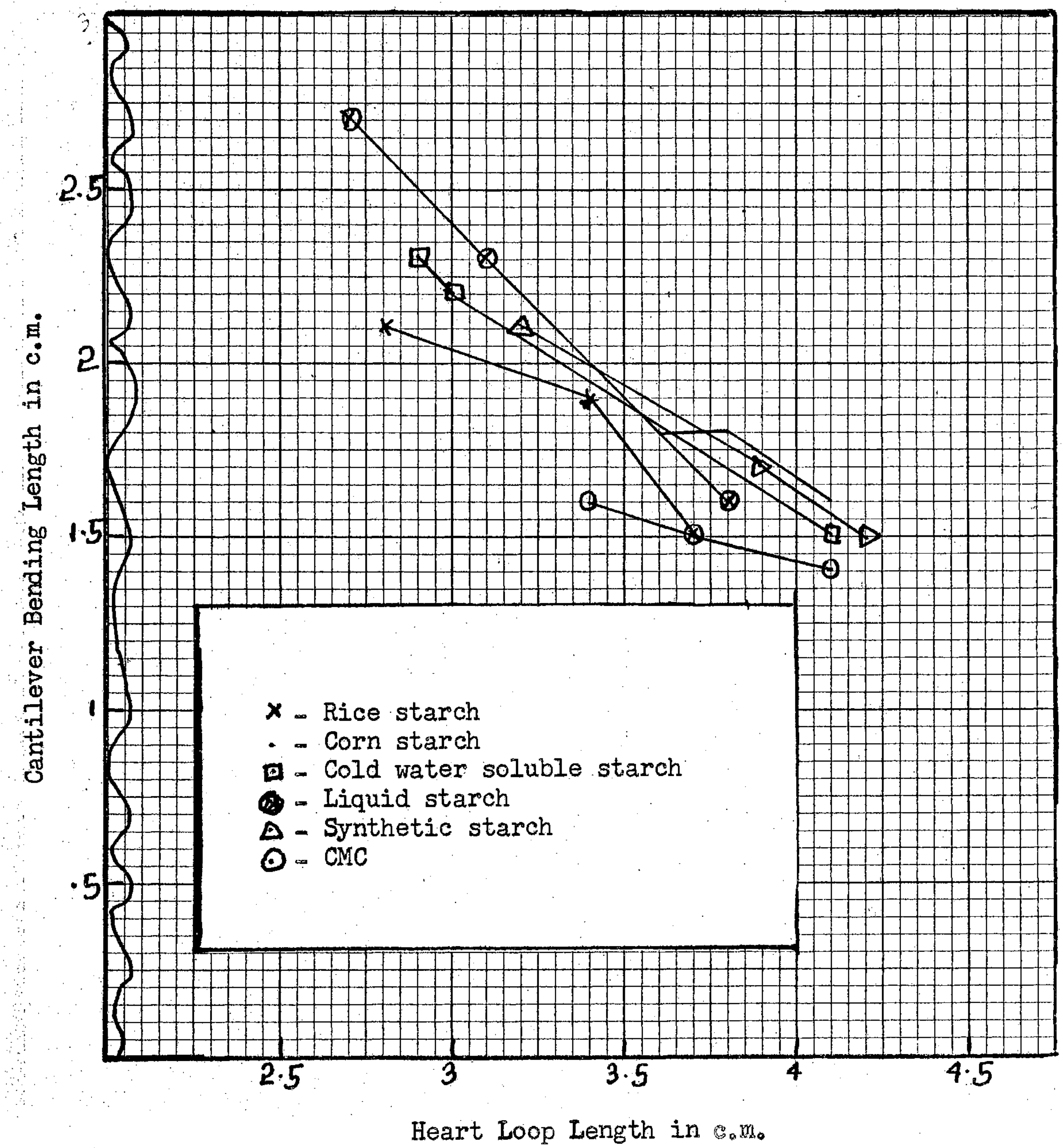

Figure 3. The Relationship Between Cantilever and Heart Loop Methods for Measuring Stiffness in the Warp Direction

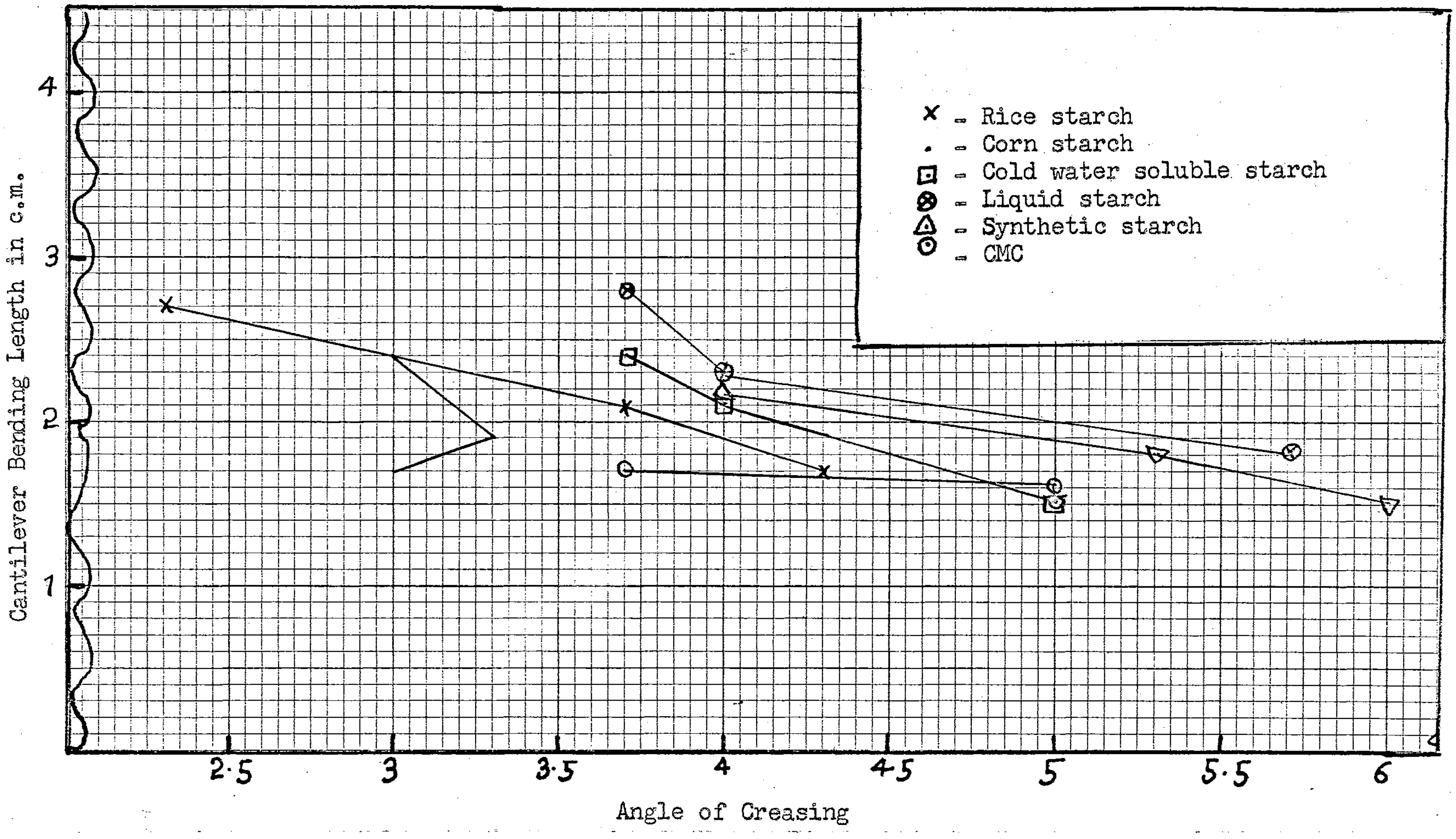

Figure 4. The Relationship Between Cantilever and Angle of Creasing Methods of Measuring Stiffness in the Filling Direction

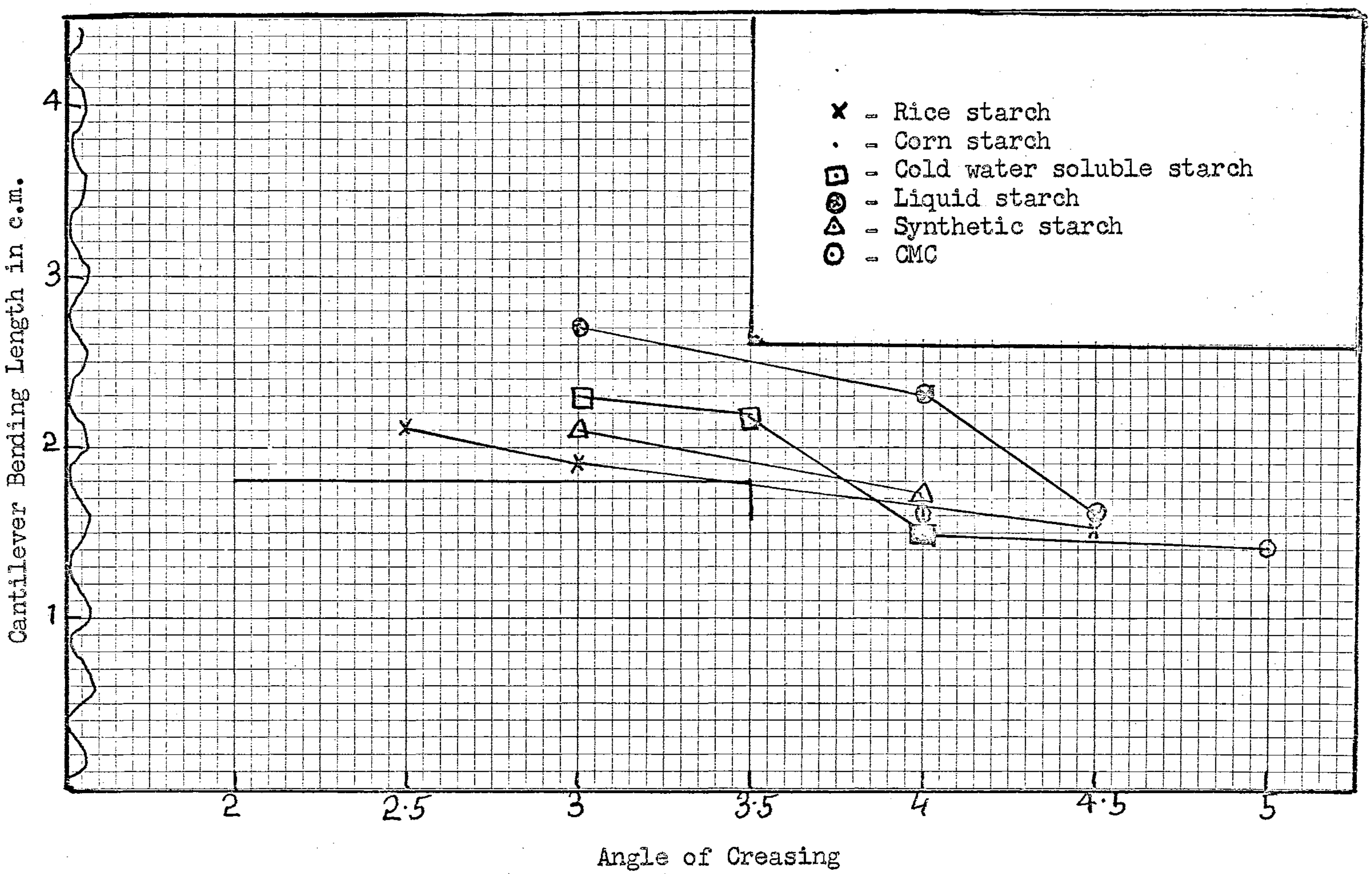

Figure 5. The Relationship Between Cantilever and Angle of Creasing Methods of Measuring Stiffness in the Warp Direction

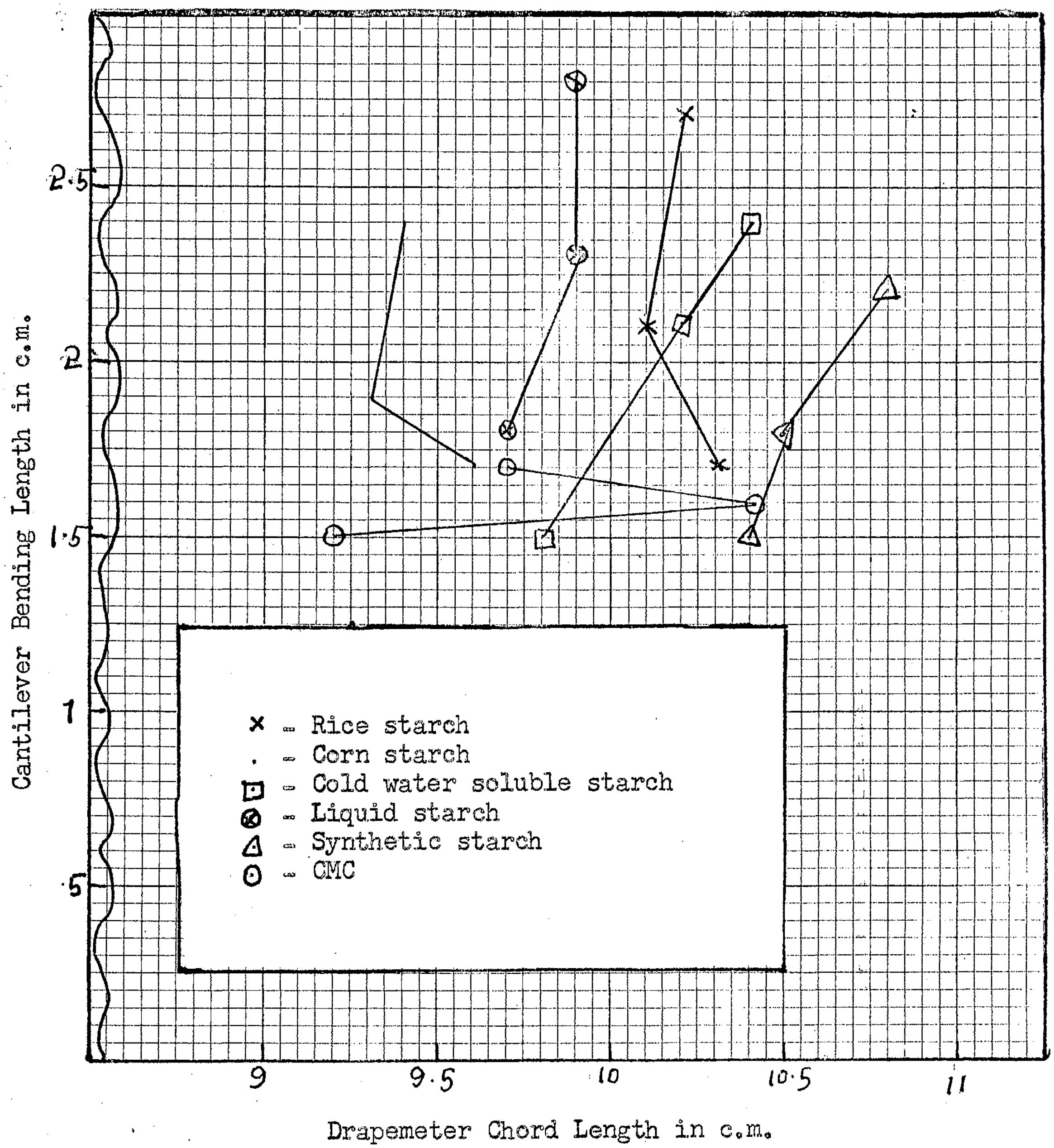

Figure 6. The Relationship Between Cantilever and Drapemeter Methods of Measuring Stiffness in the Filling Direction

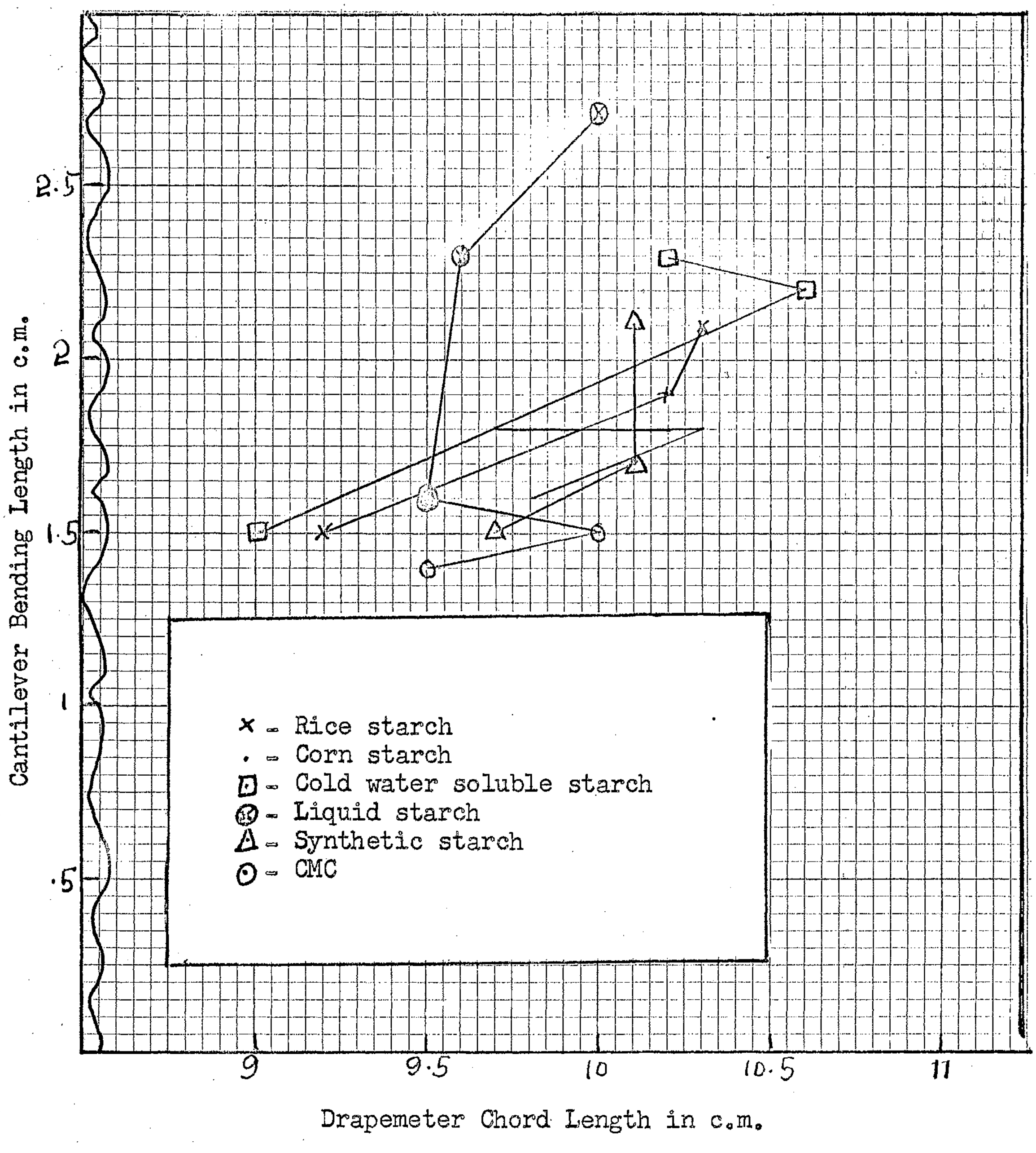

Figure 7. The Relationship Between Cantilever and Drapemeter Methods of Measuring Stiffness in the Warp Direction

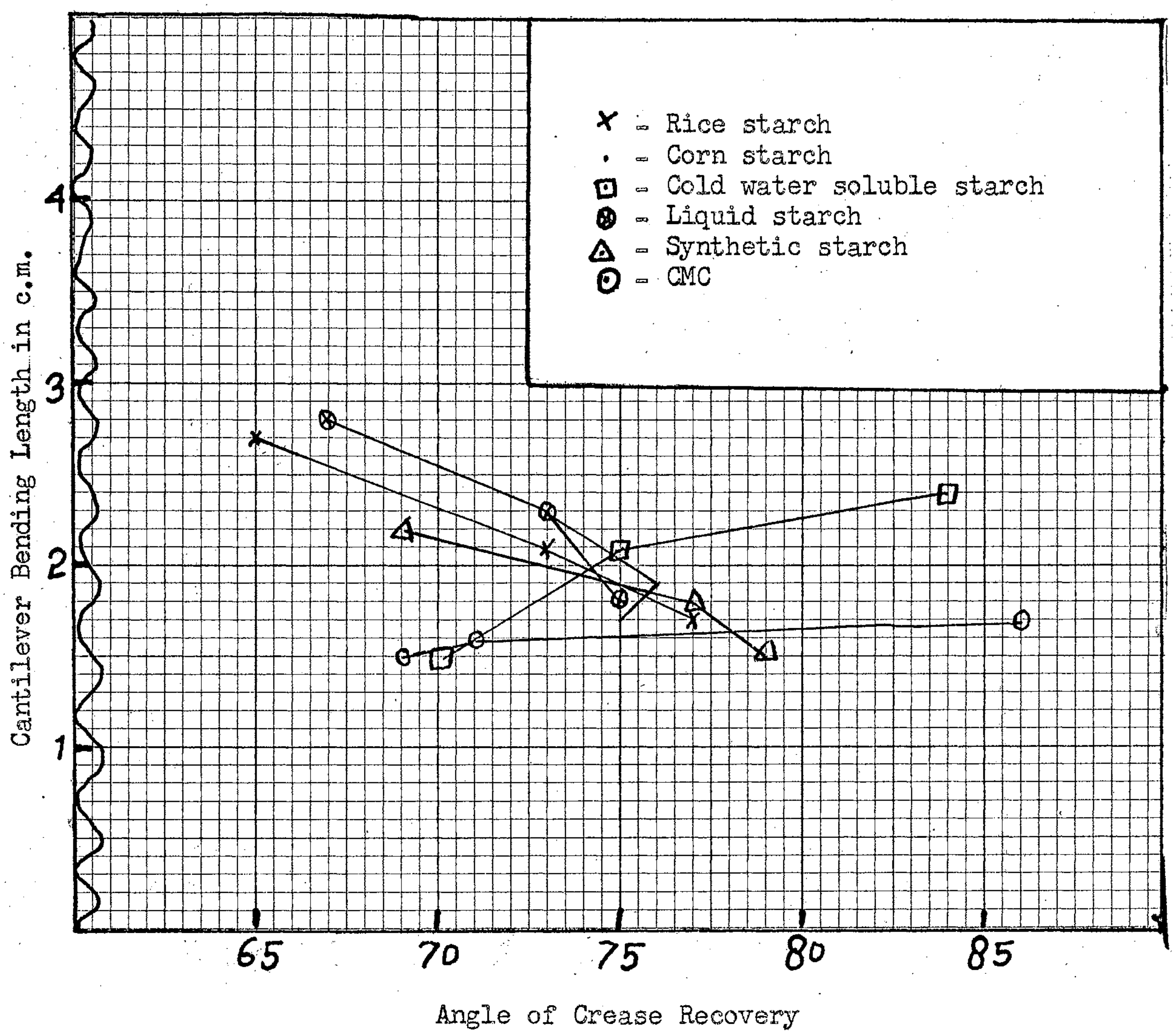

Figure 8. The relationship Between Stiffness (Cantilever) and Crease Recovery (Angle) in the Filling Direction

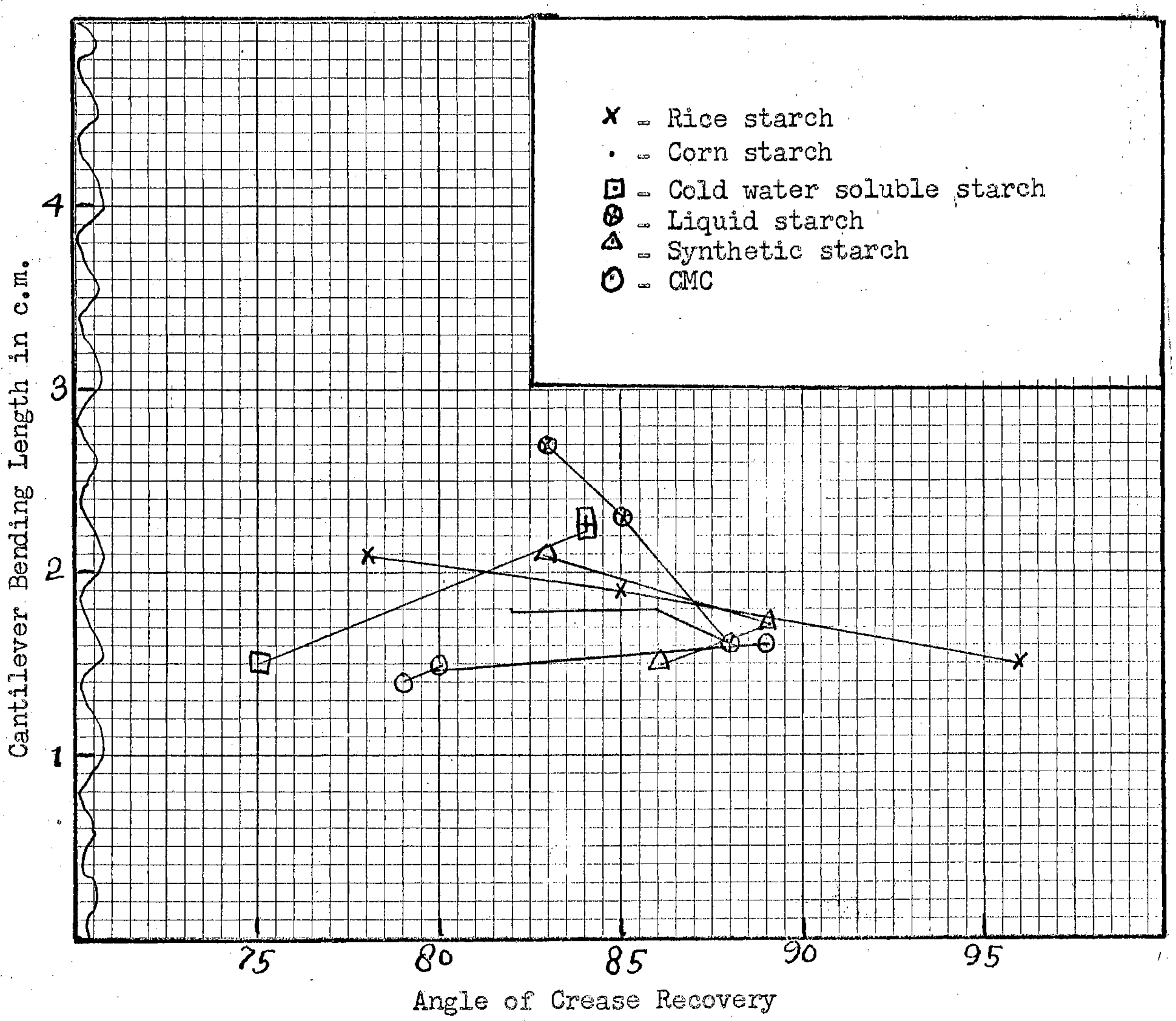

Figure 9. The relationship Between Stiffness (Cantilever) and Crease Recovery (Angle) in the Warp Direction

VITA

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