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Study on mechanical and comfort properties of mulberry silk union fabric

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Abstract
Mulberry silk is a kind of fibre that is well-known for its lustre look and handling qualities, making it a significant natural source for textiles. The most basic need for survival of people is clothes. Clothing can be created from both man-made fibres like rayon and nylon and natural fibres like cotton, wool, silk, hemp, and linen. A textile that utilises different threads for both the warp and weft is referred to as a union fabric. In order to produce a new fabric with the combined properties of the two yarns, these textiles blend the properties of two different yarns. Therefore, the purpose of this study is to familiarize with the mechanical and comfort properties of constructed woven fabrics.

Keywords: Mechanical, comfort properties, mulberry silk union fabric

Introduction
The sheen, luxurious appeal, comfort, grace, elegance, and glamour of silk have earned it the title of "Queen of Textiles" in the world of fashion. Silk is a fibre for high-design clothing because of its inherent beauty, good drape ability, comforting characteristics, and capacity to maintain warmth throughout winters (Kumar *et al*., 2020) [3]. One of the well-known varieties of silk is mulberry silk. This fibre type is a significant natural source for textiles, especially because of its shiny look and handling characteristics. Even if its features allow the production of fibre by it, blending with other fibre types might be selected to reduce the cost of raw materials and increase affordability. Due to its ability to be a textile material, cotton might be an ideal partner for this fibre type (Uzumcu *et al*., 2019) [6]. Silk is a long, slender, light, and silky fibre. It is known for its lustre, thermal conductivity, affinity for dyeing, water absorption, and insulating characteristics. According to Jeyaraj (2015) [2], silk has numerous luxury advantages, such as being absorbent, sturdy, wrinkle-resistant, mildew- and moth-resistant, and non-melting dyes in beautiful, rich hues. The mechanical, performance, durability and comfort qualities of woven materials can all be investigated separately. Fabric density is determined by the interlacing of warp and weft yarns, which are retained under the necessary tension and by variations in the yarn linear densities, which are revealed by mechanical qualities (Medar and Mahale, 2018) [5]. The present research work on “Study on mechanical properties of Mulberry Silk Union Fabric” was taken with the following objectives-

- To construct Mulberry Silk union fabric with Cotton and Polyester using plain and twill weave.
- To study the mechanical and comfort properties of Mulberry Silk Union Fabric

Methodology
Union textiles are those in which the warp and weft are distinct. Mulberry x Mulberry was used as the control sample in this investigation, and union fabrics made of Mulberry x Cotton and Mulberry x Polyester were developed. For the production of union textiles, Mulberry silk was utilised in the warp direction and Cotton and Polyester in the weft direction. The two distinct weaves, used were plain and basket weaves. Fabric count (numerical expression), fabric weight, fabric thickness (mm), cover factor (numerical expression), and crease recovery (degree) are mechanical properties of yarns that have been calculated.

Mechinal properties of Mulberry Silk Union Fabric

Fabric count (thread/inch)

The number of warp (ends) and weft yarns (picks) in a woven textile material are known as the fabric count. A pick glass was used to calculate the count according to the I.S. technique (1963–1969). For this, a small pocket magnifying glass called pick glass was employed. Warp and weft yarn were parallel to the pick glass's sides when it was positioned on the cloth. Selvedge were avoided since their thread spacing differs only slightly from that of the fabric's body. The cloth under the pick glass was maintained under zero tension and wrinkle-free. Five readings were obtained in the warp and weft directions to obtain an accurate value as per Booth, 1968 [7].

Table 1: Fabric count of the constructed fabric

Fabrics	Fabric Counts(thread/inch)			
	Plain		Twill	
	Warp (EPI)	Weft (PPI)	Warp (EPI)	Weft (PPI)
MM	62	64	61	64
MC	59	63	56	64
MP	63	72	58	70

The table 1 showed that Mulberry x Polyester had the highest fabric count in the warp direction of plain weave (63 EPI), followed by Mulberry x Mulberry (62 EPI), and Mulberry x Cotton (59 EPI). Mulberry x Polyester in plain weave had the highest weft count across all samples (72 PPI), followed by Mulberry x Mulberry (64 PPI) and Mulberry x Cotton (63 PPI). From the above data, it can be concluded that the beating process used in weaving, the compactness of the weave, and the yarn count were responsible for the variation in fabric count in plain and twill woven fabric of Mulberry silk union textiles.

Table 1 shows that the highest fabric count in the warp direction of twill weave was Mulberry x Mulberry (61EPI), followed by Mulberry x Polyester (58EPI) and Mulberry x Cotton (56EPI). All of the samples' weft counts were different, with Mulberry x Polyester in twill weave having the highest weft count (70 PPI), followed by Mulberry x Mulberry (64 PPI), and Mulberry x Cotton (64 PPI). From the above data, it can be concluded that the beating process used in weaving, the compactness of the weave, and the yarn count were responsible for the variation in fabric count in plain and twill woven fabric of Mulberry silk union textiles.

Fabric weight (g/sq.mt)

The weight of fabric is measured in grams per square metre. An electronic weighing balance was used to weigh the textiles. A sample of 5 × 5 cm is cut and measured on an electronic weighing scale to calculate the weight per square metre as per Booth, 1968 [7]. After that, the warp and weft threads are divided and weighed to determine the respective percentage.

Table 2: Fabric weight of the constructed fabric

Fabrics	Fabric Weight (g/sq.mt)	
	Plain	Twill
MM	0.8	0.8
MC	0.6	0.9
MP	0.5	0.6

Table 2 revealed that fabric weight of Mulberry x Mulberry in plain weave found highest (0.8 g/sq.mt) followed by Mulberry x Cotton (0.6 g/sq.mt) and Mulberry x Polyester (0.5 g/sq.mt). It can be concluded from the table that the Mulberry x Mulberry union fabric showed highest fabric weight. This may be due to the increase thickness and stiffness.

Table 2 revealed that fabric weight of Mulberry x Cotton in twill weave found highest (0.9 g/sq.mt) followed by Mulberry x Mulberry (0.8 g/sq.mt) and Mulberry x Polyester (0.6 g/sq.mt). It can be concluded from the table that the Mulberry x Cotton union fabric showed highest fabric weight. This may be due to the coarser yarn structure and less yarn count.

Fabric thickness (mm)

The distance between the upper and lower surface of the textile material measured under a specific pressure is called fabric thickness. By using Shirley's thickness tester, as directed in IS-7702-1975 the fabric thickness was calculated. The thickness gauge has an anvil upon which a pressure foot is pressed by spring and a clock type dial is built into a thickness tester. Before conducting the procedure, it should be mounted into a frame and adjusted to zero. The sample was kept on the anvil and presser foot was lowered by releasing the lever very slowly. The dial refers the thickness of the samples in mm. The samples should be free from, wrinkles, crashing or distortions, abnormal to test material. The sample was tested in 10 different locations randomly and the mean value was taken as per Booth 1968 [7].

Table 3: Fabric thickness of the constructed fabric

Fabrics	Fabric Thickness (mm)	
	Plain	Twill
MM	0.21	0.36
MC	0.21	0.32
MP	0.26	0.31

Table 3 depicts that fabric thickness of Mulberry x Polyester in plain weave found maximum (0.26 mm) followed by Mulberry x Cotton (0.21 mm) and Mulberry x Mulberry (0.21 mm). This may be due to the beating process and number of yarn count.

Table 3 depicts that fabric thickness of Mulberry x Mulberry in twill weave found highest (0.36 mm) followed by Mulberry x Cotton (0.32 mm) and Mulberry x Polyester (0.31 mm). Twill woven fabric showed highest thickness. This may be due to fabric weave as well as the thread position in the binding repeat.

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Cover factor (numerical expression)

The openness or closeness of a fabric is expressed by cover factor in fabric terminology. It is calculated by the formula –

$K = n/\sqrt{N}$

Where,

K =Cover factor

n=Threads per inch

N= Count of yarn

Cover factor are calculated for both warp and weft separately. Further, the cloth cover factor was calculated by the following formula (Booth 1968) [7];

$$k_c = k1 + k2 - \frac{k1\ k2}{28}$$

Where,
Kc = cloth cover factor,
K1 =Warp cover factor
K2= Weft cover factor

Table 4: Cover factor of the constructed fabric

Fabrics	Cover Factor(numerical expression)			
	Plain		Twill	
	Warp	Weft	Warp	Weft
MM	17.32	10.02	18.02	12.27
MC	16.39	18.07	18.62	13.06
MP	15.59	20.67	15.72	21.07

Table 4 indicated that Cover factor of Mulberry x Mulberry in warp direction of plain weave fabric found maximum (17.32) and followed by Mulberry x Cotton (16.39) and Mulberry x Polyester (15.59). In weft direction, the Cover factor of all the samples found maximum in Mulberry x Polyester (20.67) followed by Mulberry x Cotton (18.07) and Mulberry x Mulberry (10.02). The value of cover factor was maximum in Mulberry x Mulberry of plain woven fabric which has more interlacing points and more numbers of pores with less cross sectional area.
Table 4 showed that Cover factor of Mulberry x Cotton in warp direction of twill weave fabric found maximum (18.62) and followed by Mulberry x Mulberry (18.02) and Mulberry x Polyester (15.72). In weft direction, the Cover factor of all the samples found maximum in Mulberry x Polyester (21.07) followed by Mulberry x Cotton (13.06) and Mulberry x Mulberry (12.27).
The results revealed higher cover factor value in Mulberry x Cotton of twill woven fabric which has more interlacing points and more numbers of pores with less cross sectional area. Cover factor determines the appearance, handle, feel, permeability and transparency, limits of pick insertion and texture of the fabric.

Crease recovery (degree)
Crease recovery is the ability of a textile material to recover from the creases. By using the Shirley's crease tester, the samples were tested as directed in IS method 4681-1968. It has a circular dial with a clamp that holds the specimen and under the centre of the dial, a knife edge and an index line is placed for measuring the recovery angle. The scale is engraved on the dial. With the help of a template, 10 specimens were cut in warp and weft direction from the fabric, 2 inch long and 1 inch wide. The samples were folded in half, placed between two glass plates, and given a 5 kg weight to cause creases. The weight was taken out of the crease after five minutes. In order to maintain the specimen's free edge in contact with the knife edge while it recovers, the instrument's dial was rotated. The recovery angle in degrees was read from the engraved scale at the end of the specified recovery time, which was usually 1 minute as per Booth, 1968 [7].

Table 5: Crease Recovery of the constructed fabric

Fabrics	Crease Recovery (Degree)			
	Plain		Twill	
	Warp	Weft	Warp	Weft
MM	60	60	82	84
MC	60	71	60	63
MP	73	72	80	82

According to Table 5, the maximum degree of crease recovery was found in the warp direction of plain weave fabrics made of a union of mulberry and polyester (73 degrees), followed by mulberry and cotton (60 degrees) and mulberry and mulberry (60 degrees). Mulberry x Polyester (72 degrees), Mulberry x Cotton (71 degrees), and Mulberry x Mulberry (60 degrees) had the greatest crease recovery in the weft direction. From the above data, it can be concluded that Mulberry x Polyester showed highest crease recovery, maybe as a result of the strong resilience of Mulberry and Polyester yarn.
According to Table 5, the maximum degree of crease recovery was found in twill weave fabrics made of Mulberry x Mulberry in the warp direction (82 degrees), followed by Mulberry x Polyester (80 degrees) and Mulberry x Cotton (60 degrees). Mulberry × Mulberry had the highest Crease recovery of all the samples in the weft direction (84 degrees), followed by Mulberry x Polyester (82 degrees), and Mulberry x Cotton (63 degrees). It can be concluded from the above table that the high resilience of Mulberry yarn may be the reason why the crease recovery in Mulberry x Mulberry woven fabric was found to be greater.

Comfort properties of Mulberry Silk Union Fabric
Fabric Wicking (cm)
According to Miller (1985) [4], wicking is the term for the spontaneous absorption of liquid into a fabric, which may occur when a porous fabric comes into contact with liquid. The ability of a fabric to move absorbed sweat away from the place of absorption, often the skin, and the speed at which it does so is known as wicking. In a reservoir of distilled water, a length of test specimen that had been pre-conditioned at 25 °C with 65° relative humidity was suspended. The height that the distilled water in the fibres reached over the water level in the reservoir was measured and recorded (at a continuous time of 2 minutes).

Table 6: Fabric wicking of the constructed fabric

Fabrics	Fabric Wicking(cm)			
	Plain		Twill	
	Warp	Weft	Warp	Weft
MM	3.1	3.0	3.2	3.5
MC	3.3	3.1	3.1	3.2
MP	2.8	2.7	2.4	2.6

According to Table 6, Mulberry x Cotton had the highest fabric wicking in the warp direction of plain weave fabrics (3.3 cm), followed by Mulberry x Mulberry (3.1 cm), and Mulberry x Polyester (2.8 cm). Mulberry x Cotton (3.1 cm), Mulberry x Mulberry (3.0 cm), and Mulberry x Polyester (2.7 cm) had the greatest weft-direction fabric wicking. As shown in Table 6, Mulberry x Mulberry fabric wicks the most moisture in the warp direction of twill weave fabrics (3.2 cm), followed by Mulberry x Cotton (3.1 cm), and Mulberry x Polyester (2.4 cm). Mulberry x Cotton was the fabric with the greatest weft wicking (3.5 cm), then Mulberry x Mulberry.
This could be due to water transfers more easily in the warp direction than the weft direction. According to Gokarneshan (2004) [1], this has been attributed to the creation or building of floats. Higher wicking heights showed more absorbency and may be the result of cellulose mass having enough gums and other intercellular materials removed.

Fabric Absorption (%)

Table 7: Fabric absorption of the constructed fabric

Fabrics	Fabric Absorption (%)	
	Plain weave	Twill weave
MM	3.1	3.2
MC	3.5	3.7
MP	2.7	3.0

The Table 7 showed that Mulberry x Cotton in plain weave had the greatest fabric absorption rate (3.5%), followed by Mulberry x Mulberry (3.1%) and Mulberry x Polyester (2.7%). This can be because cotton fabrics have the maximum absorption capacity.
According to the Table 7, Mulberry x Cotton in twill weave had the greatest fabric absorption rate (3.7%), followed by Mulberry x Mulberry (3.2%) and Mulberry x Polyester (3.0%). This can be because cotton fabrics have the maximum absorption capacity. This could be caused by the fabric's surface tension, kind of yarn structure, or fabric structure.

Air permeability ($cm^3/cm^2/sec$)

A fabric's air permeability is determined by how much air, expressed in cubic centimetres per second, can move through a square inch of the material at a pressure equal to one centimetre of water. The Shirley's Air Permeability Apparatus was used to test the test samples in accordance with I.S method 11056 as per Booth, 1968 [7]. Using a suction pump, air at standard pressure was pulled through the test specimen from the lab, with the flow rate being managed by a by-pass valve and a series valve. A draught gauge with a graded range of 0 to 25 mm head of water was used to show the needed pressure drop over the cloth. The suction pump's rate of air flow through the specimen was inadequate for textiles with high resistance; this was fixed by opening the by-pass valve, which provided air directly to the pump. Any disturbance brought on by the varied air stream velocity pulled by the pump through the various channels was smoothed down by a reservoir. The rate of flow of air was read off one of the four Rotameters, chosen based on the permeability of the test specimen, when the requisite pressure drop, which was typically 1 cm of water, was achieved and the indicator of the draught gauge was stable. Since a circle with a diameter of 1 inch was visible when the specimen was clamped in the holder, the test area was 5.07cm2. By dividing the average flow rate from five samples by 5.07, the fabric's air permeability in cubic centimetres per second at one centimetre of water pressure was determined. Thus, the following formula is used to determine air permeability:

$$\text{Fabric air permeability} = \frac{\text{Mean rote meter reading}}{\text{Test area}}$$

Table 8: Air permeability of the constructed fabric

Fabrics	Air permeability ($cm^3/sec\ cm^2$)	
	Plain	Twill
MM	2000	2000
MC	1500	1900
MP	1900	1500

According to Table 8, Mulberry x Mulberry plain weave fabric has the maximum air permeability (2000 cm3/sec/cm2), followed by Mulberry x Polyester (1900 cm3/sec/cm2) and Mulberry x Cotton (1500 cm3/sec/cm2). From Table 8, it was clear that Mulberry x Mulberry had the maximum air permeability in twill weave fabrics (2000cm3/sec/cm2), followed by Mulberry x Cotton (1900cm3/sec/cm2) and Mulberry x Polyester (1500cm3/sec/cm2). This could be caused by the fabric's high porosity and reduced thickness.

Fabric drapability (%)

A fabric's drape is its ability to give on an elegant aspect while in use. A fabric's drape may be defined as how much it affects when allowed to hang under its own weight. The area that the draped specimen's shadow covers, given as a percentage of the fabric's annular ring area, is known as the drape coefficient. The "Eureka drape metre" was employed to assess the textiles' drape ability. Using a circular template, specimens with a diameter of 30 cm were cut out and stored on the drape meter's support disc. When the light is turned on, it produces the draped area's shadow, which was recorded on paper and weighed. The template's draping shadow area and supporting disc were both taken similarly. As a result, the formula was used to derive the Drape coefficient as per Booth, 1968 [7].

$$F = \frac{As - Ad}{AD - Ad} \times 100$$

Where,
As= weight of the actual projected area of the specimen
AD= Weight of the specimen
Ad= Weight of the supporting disc.
F= Drape co-efficient.

Table 9: Fabric Drapability of the constructed fabric

Fabrics	Fabric Drapability (%)	
	Plain	Twill
MM	47.09	48.70
MC	49.01	53.05
MP	55.02	56.72

According to Table 9, Mulberry x Polyester in plain weave had the greatest fabric drapeability (55.02%), followed by Mulberry x Cotton (49.01%) and Mulberry x Mulberry (47.09%). According to Table 9, Mulberry x Polyester in twill weave had the greatest fabric drapeability (56.72%), followed by Mulberry x Cotton (53.05%) and Mulberry x Mulberry (48.70%). This may be due to less stiffness low weight and less thickness.

Conclusion

Weaving union fabrics of Mulberry x Cotton and Mulberry x Polyester in a plain and twill weave has been attempted in this study. Mulberry x Mulberry plain and twill weave fabrics were also woven at the same time for comparison. In addition to comfort parameters like fabric wicking, fabric absorption (%), air permeability (cm3/cm2/sec), and fabric drapability (%), mechanical properties including fabric weight, fabric count, cover factor, thickness, and crease recovery were evaluated.

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