Guru Nanak Khalsa College for Women
Gujarkhan Campus, Model Town, Ludhiana

3.3.2.1 Number of research papers per teachers in the Journals notified on UGC website during the year (2021-2022)

Title of paper	Name of the author/s	Department of the teacher	Name of journal	Year of publication	ISSN number	Link to the recognition in UGC enlistment of the Journal
A comparative study on Pilling Performance of Mulberry silk/ viscose blended fabrics for apparel use	Dr. Shikha Bajaj	Department of Fashion Designing	Anvesak	2021	0378 – 4568	https://ugccare.unipune.ac.in/Apps1/User/WebA/SearchList
Students Perception towards service Quality of Higher Education in Foreign Institutions: A Factor Analysis	Dr. Punpreet Kaur	PG Department of Commerce	Kanpur Philosophers	2022	2348-8301	https://journalppw.com/index.php/jpsp/article/view/3733
The effect of Demographic Factors on Determinants of Students Destination Choice for Higher Education in Foreign Institutions	Dr. Punpreet Kaur	PG Department of Commerce	Journal of positive School Psychology	2022	2717-7564	NIL
Highlights of National Education Policy 2020 in relevance to Higher Education	Mrs. Rajwinder Kaur	PG Department of Commerce	International Research Journal of Management and Commerce	2022	2348-9766	NIL

Dr. Maneeta Kahlon

Principal

Dr. MANEETA KAHLON
Principal
G.N.Kh. College for Women
Gujarkhan Campus, Model Town,
Ludhiana

1. https://ugccare.unipune.ac.in/Apps1/User/WebA/SearchList
2. https://journalppw.com/index.php/jpsp/article/view/3733

A COMPARATIVE STUDY ON PILLING PERFORMANCE OF MULBERRY SILK/ VISCOSE BLENDED FABRICS FOR APPAREL USE

Dr Shikha Bajaj
Assistant Professor, Guru Nanak Khalsa College for Women, Ludhiana.

Dr Sandeep Bains
Dean, College of Community Science, Punjab Agricultural University, Ludhiana.

Abstract
Mechanical characteristics are very important for any fabric. Pilling is a common and unanswered issue and causes unappealing appearance and uncomfortable wear. In the present investigation, pilling properties of mulberry silk and viscose blended knitted fabrics were studied. Attempt was made on six knitted fabrics, blended in proportions of 60% mulberry silk: 40% viscose, 50% mulberry silk: 50% viscose and 40% mulberry silk: 60% viscose, each in two unequal counts. Objective assessment of the fabrics has been carried out in order to obtain the scores on pilling. Parameters like yarn hairiness, yarn unevenness were selected for experimental design. Blended knitted fabrics were subjected to tests for prediction of pilling resistance. The results could bring about the useful data for comparison of fabric quality. Linear relationships were obtained among pilling resistance and other yarn parameters. It was witnessed that knitted fabric blended in proportion of 40% mulberry silk: 60% viscose in 20 Nm yarn count carried highest grade (4.012) for pilling; hence same was recommended for apparel use, commercial handling and production.

Keywords: *Blended, Fibres, Pilling, Property, Yarns*

1. Introduction

Pilling in fabrics is deep rooted complication. It is degradation of fabric surface giving loathsome appearance. The complication mostly occurs in knitted fabrics. Also pilling reduces the life duration clothes and if increased, pilling can even lead to holes (Kayseri and Kirtay 2015).

The pills are made by use and washing, and which reveals that pills are formed by friction during wear. Forces of friction leads to abrasion and pill formation in fabrics. With result, the is relation between abrasion and pilling. The method of fabric construction is also a crucial factor for analyzing its susceptibility to pilling. Tight show less wear and tear and thus show less pilling. Pills do not make any interference with the usage of the textile fabric, unless pills together make a hole. This happens because both pills and holes are made by the fabric wearing (Lee et al 1996).

As per the past researches, different fibres, yarns and fabric properties largely affect the properties of fabric at the end. Type of fabric, its basic parameters like length, fineness and cross sectional shape, other properties like friction among fibres, bending resistance, spinning method utilized, twist, hairiness, fabric weight etc are important features of influencing the tendency of pilling in fabrics (Ukponmwan 1998).

However, pilling of knitted fabrics products is an undesirable phenomenon during wearing and laundering that affects the handle and appearance and greatly shortens the service life of the products.

In the present paper, authors have intended to compare the pilling resistance of blended knitted fabrics developed in two different counts.

2. Objectives

-To compare the pilling properties of blended knitted fabrics developed in two unequal counts.

- To analyze the relationship of pilling resistance with other fabric properties.

3. Materials

Mulberry silk and viscose fibres used in the study were supplied from different regions, having different physical properties. Raw material was supplied in fibre form and yarns were developed thereafter.

The yarns were spun in Ne 15 and Ne 20 linear densities and in three different compositions *viz* 60% mulberry silk: 40% viscose, 50% mulberry silk: 50% viscose and 40% mulberry silk: 60% viscose. The twist coefficients were selected according to the mostly used twist factors in knitting industry. Therefore totally 6 different yarns were produced in the same production conditions. The production of the single jersey knitted fabrics was realized by using 10 gauge sinker circular knitting machine. For both the fibres utilized for study, physical properties have been given in table 1.

Table 1 Physical parameters of mulberry silk waste and viscose fibre

Physical parameters	Mulberry silk waste	Viscose
Fibre length (cm)	130.667	139.789
Maximum length	152	164
Minimum length	94	99
Effective length	135	145
Short fibre % < 20 cm	8.04	6.31
Fineness (denier)	1.87 ± 0.045	3.96 ± 0.119
CV %	13.11	16.39
Fibre diameter (microns)	12.73 ± 0.226	27.46 ± 0.364
CV %	25.14	18.76

Mean value ± Standard error

CV (%) = Per cent coefficient of variation

3.1 Fibre length

It is evident from the results presented in table 1 that that both mulberry silk waste and viscose fibre were continuous filament fibres. Before initiation of blending viscose fibres were cut into shorter lengths in order to match fibre length of mulberry silk waste. Mulberry silk waste exhibited a mean length of 130.667 cm and viscose fibre had a length 139.789 cm. Maximum length for mulberry silk waste fibre was observed as 152 cm, however same was measured as 164 cm for viscose fibre. Minimum length in case of mulberry silk waste fibre was 94 cm, whereas, for viscose fibre, it was calculated as 99 cm. Effective length for mulberry silk waste and viscose fibres was calculated as 135 cm and 145 cm respectively. The per centage of short fibres (< 20 cm) for mulberry silk waste fibres was computed as 8.04 per cent, whereas, for viscose fibre, it was computed as 6.31 percent. Since both were continuous filament fibres, high suitability of lengths in blending was observed.

3.2 Fibre fineness

Final properties of fabric are directly affected by fineness of the yarn. Mulberry silk waste fibre was found to be finer than viscose fibre. Fineness of mulberry silk waste was 1.87 ± 0.045 denier and that of viscose fibre was 3.96 ± 0.119 denier (Table 1). Fineness of silk filament greatly depends on position filament in cocoon. In a study by Gupta *et al* (2000), average fineness of mulberry silk was found to be 1.354 denier.

3.3 Fibre diameter

Diameter of mulberry silk was found to be 12.73 ± 0.226 microns. The coefficient of variation was 25.14 per cent. According to Teresinha (2017), mulberry silk fibre is 10 to 14 microns in diameter. In case of viscose fibre, diameter was measured as 27.46 ± 0.364 microns (Table 1).

3.4 Fibre crimp

Fibre crimp in mulberry silk waste had a mean value of 5.333 ± 0.333 arcs/ cm. Coefficient of variation was 10.825 per cent. In case of viscose fibre, number of crimps per cm were found to be 1.333 ± 0.333 arcs/ cm (Table 1). Coefficient of variation was found to be 43.301 per cent. It is evident from the results that mulberry silk fibre was slightly more crimped than viscose fibre. Matsudaira *et al* (2008) in their study, investigated relation between fibre crimp and fibre quality. It was reported that fibre crimp has major impact over extensibility, compressibility and final quality of fibre is improved with fabric extensibility. Correlation between fibre crimp and primary handle is also investigated, and it was found that NUMERI (smoothness) and FUKURAMI (fullness and softness) are strongly correlated with the fibre crimp.

4. Methods

4.1 Development of blended yarns

A worsted spinning system was used to blend mulberry silk waste and viscose fibres. Yarns were developed in two different counts. Mulberry silk waste was opened properly by hand and then was fed into carding machine. Further to this, the fibres were blended using gillbox. At this step, fibres were blended in three different ratios i.e. 60:40, 50:50 and 40:60. After this, drawing procedure was carried out. Sheikhi *et al* (2012) also used gill box machinery for blending of acrylic fibres with varying fineness. Since, twist per inch is a parameter that influences output behavior of yarns, it was viewed as being held constant. Variables are viewed as changing while parameters typically either don't change or change more slowly (Nykamp, 2012), therefore, all the yarns were incorporated with same amount of twist (10 twists per inch). The developed yarn cones weighed 50 g each.

Table 2 Constructional properties of developed yarns

Blending proportion (Mulberry silk %: viscose %)	Yarn count (Nm)	Twist per inch (TPI)
60: 40	15	10
60: 40	20	10
50: 50	15	10
50:50	20	10
40: 60	15	10
40: 60	20	10

4.2 Determination of yarn properties

Blended yarns were tested physically and mechanically. Physical properties like yarn unevenness and yarn hairiness were analysed. Twist per inch was kept constant for the yarn proportions in both the counts.

4.2.1 Yarn unevenness (ASTM D-1425-1996)

Yarn unevenness per centage is the percentage mass deviation of unit length of material and is caused by uneven fibre distribution along the length of the strand (Anonymous, 2014). Uster Tester-5 was used for checking yarn unevenness. This machine can calculate imperfections in yarn at different levels. It is an electronic instrument which works on electronic capacitance tester principle. It carries two oscillators having equal frequencies. When these two frequencies superimpose, the frequency difference becomes zero. If material to be tested is present in the capacitor, the frequency of oscillator is changed. In this case, difference between frequencies is not zero and it varies depending upon the sample being tested. Appropriate circuit converts the frequency difference into signals to be entered into the integrator. Integrator in the end, expresses the mean irregularity as unevenness per cent and coefficient of variation per cent.

The equipment used can indicate number of imperfections (thick places, thin places and neps) measured at following sensitivity settings.

Thin places	-50 %	-40 %	-30 %
Thick places	+35 %	+ 50 %	+ 100 %
Neps	+ 140 %	+ 200 %	

First of all, the material to be tested was conditioned in standard atmospheric conditions. The equipment was switched ON, after which it starts self test. After completion of self tests, START button was pressed. Staple length, fibre fineness and unit speed were set on the instrument. For fibre length upto 40 mm, option “short staple” was selected. For fibres above 40 mm length, option with “long staple” was selected. After this, ‘test parameter’ button was pressed. Values for sample identification, characteristic values and measuring conditions were fed into the machine giving required information. A speed of 400 m/ min was selected. The yarn was fed into the machine passing through few guides and START button was pressed. The test was conducted five times by using yarn from five different cones. Computer installed alongwith the instrument provided results in printed form revealing the number of imperfections (thin places, thick places and neps) and unevenness per cent.

4.2.2 Yarn hairiness (ASTM D-5647-07)

Uster tester was used for measurement of hairiness in yarn. The device measuring hairiness has to be attached separately to uster evenness tester by removing normal measuring capacitor. A parallel beam of infra red radiations is passed through the measuring head and yarn is illuminated. Light is scattered by the fibres, however light scattered by protruding fibres from the main fibre body ultimately arrives the light detector. An opaque stop hinders or blocks the direct light from reaching the detector. In this way, the amount of scattered light is measured by the instrument, which is “measure of hairiness” in yarn. It is then translated into electrical signal by the device. This instrument monitors only the total hairiness, however, by using uster evenness data collection system, one can also see the changes occurring in hairiness along the yarn. This is indicated by using a diagram called spectrogram, CV of hairiness and mean hairiness in way similar to that used for unevenness testing. Five readings were taken by taking yarn from five different cones. Each time results were given in printed form by computer installed with the equipment providing number of hairiness in yarn.

After development of knitted fabric on circular knitted machines, pilling resistance was calculated for all the blends in both the yarn counts.

4.3 Development of knitted fabric

4.3.1 Pilling resistance (IS: 10971-1984)

Pills are small knots or balls of mixture of large fibres accumulated at the surface of fabric and entangled due to frictional action during processing or wearing (Angappan and Gopalkrishnan 1997). For evaluation of pilling resistance in fabric samples, test method IS: 10971-1984 was applied. I.C. I. pill box tester was used for this test. The equipment carries two rotatable boxes at both ends. Each box carries four rubber tubes which are 6 inches long with outside diameter 1 ¼ inches and inside diameter 1/8 inch. Four such tubes are kept in boxes measuring 9 x 9 x 9 inches in dimensions. A piece of test specimen was cut measuring 5 x 5 inches. It was then sewn from the sides so that it fits over the rubber tube. The seam allowance was turned to inside area at the fabric tube and it was then worn over rubber tube. The procedure was repeated for all the fabric specimens. Four such tubes were kept inside one box lined cork 1.8 inches in thickness. The boxes were then rotated at a speed of 60 rpm and were set for 18000 revolutions. Machine was started and was run until it automatically stopped after 18000 revolutions. Test specimens were taken out and stitches were opened. These were compared with photographic rating standards and evaluated for extent of pilling. Photographic rating standards show levels of pilling in fabrics as under:

Rating 1 Very severe pilling
Rating 2 Severe pilling
Rating 3 Moderate pilling
Rating 4 Slight pilling
Rating 5 No pilling

5. Results and discussion

Since unevenness behavior can vary in 15 Nm and 20 Nm yarns, therefore, properties for blended yarns were calculated separately for both yarn counts and results have been furnished in table 3 and 4.

Table 3 Physical properties of blended yarns (15 Nm)

Physical parameters	Proportions			CD Overall CV %
	60% mulberry silk: 40% viscose	50% mulberry silk: 50% viscose	40% mulberry silk: 60% viscose	
Yarn unevenness				
U % CV %	28.30^{c}± 0.307 2.422	25.10^{b}± 0.376 3.345	23.78^{a}± 0.287 2.699	1.003 2.828
Thin -50 %/ km CV %	1604^{c}± 33.252 4.635	1045 ^{b}± 6.237 1.335	973^{a}± 4.159 0.956	60.670 3.644
Thick + 50 %/ km CV %	4113^{c}± 2.345 0.127	3258 ^{b}± 3.661 0.251	2820 ^{a}± 5.805 0.460	12.909 0.276
Neps + 200%/km CV %	7237^{c}± 12.505 0.386	4294 ^{b}± 8.840 0.460	4944 ^{a}± 2.818 0.127	27.889 0.368
Hairiness (-)/km	11.29^{c}± 0.075	10.58^{a}± 0.013	10.83 ^{b}± 0.140	0.159

CV %	1.151	0.205	2.235	1.059

a,b,c Significant at 5 % level of significance, same alphabet= no significant difference, different alphabet= significant difference, CD= Critical difference, NS= Not significant

5.1 Yarn unevenness for 15 Nm yarns

It is evident from table 3 that highest U % had been shown by yarn with 60% mulberry silk: 40% viscose with a mean value of 28.30 ± 0.307 per cent. The yarn with 50% silk : 50% viscose blend exhibited U % of 25.10 ± 0.376 per cent followed by yarn with 40% mulberry silk: 60% viscose blend which showed mean value of 23.78 ± 0.287 per cent. A significant difference ($p \leq .05$) was noticed among values of all the three blends. Observations reveal that unevenness in the yarns declined with decrease in silk content. This was because silk waste fibre has been used for the study which is uneven at places and irregularities in the fineness of yarn were seen. Similar trends of decrease in yarn unevenness with decrease in silk component have also been observed in a study by Verma on blending of mulberry silk waste with Australian wool fibre in 2011.

Thin places (-50%) Maximum thin places were noticed in yarn with 60% mulberry silk: 40% viscose (1604 ± 33.252 % per km) blend. The value reduced significantly ($p \leq .05$) with decrease in silk component. Thin places for yarn with50% mulberry silk: 50% viscose blend, were found to be 1045 ± 6.237 % per km. A significantly ($p \leq .05$) low number of thin places were calculated for yarn with 40% mulberry silk: 60% viscose blend with mean value of 973 ± 4.159 % per km.

Thick places (-50%) The data pertaining to thick places in the yarn depicted similar significant ($p \leq .05$) decline in thick places with decrease in ratio of silk fibre. Highest value was achieved by yarn with 60% mulberry silk: 40% viscose (4113 ± 2.345 % per km) blend. Thick places of 3258 ± 3.661 % per km were found yarn with50% mulberry silk: 50% viscose blend and least number of thick places (2820 ± 5.805 % per km) were depicted by yarn with40% mulberry silk: 60% viscose blend.

Neps +200%per km From table 3, it can be observed that number of neps has been found to be significantly high ($p \leq .05$) in case of yarn with 60% mulberry silk: 40% viscose blend (7237 ± 12.505per km) in comparison to 4944 ± 2.818 / km of yarn with 40% mulberry silk: 60% viscose blend and 4294 ± 8.840per km of yarn with 50% mulberry silk: 50% viscose blend. The reason for this drop in 50% mulberry silk: 50% viscose and 40% mulberry silk: 60% viscose is fall in silk proportion. Since silk waste fibre has been used, number of neps is more in the blend where silk component is present in higher quantity. Chavan (2016) mentioned that irregularities like neps, knots, loops and snarls have now also been used as decorative features in case of fancy yarns.

It is noticeable from the findings that yarn unevenness decreased with decline in silk proportion. Similar trend has been observed for all the parameters. Mulberry silk waste fibres had more number of irregularities. Also the coefficient of variation of fibre diameter clearly reveals that there a more variation in diameter of the mulberry silk waste. The results are in line with the findings of Gahlot and Pant (2011), in which the irregularities decreased with rise in viscose content and decline in silk component.

5.2 Yarn hairiness for 15 Nm yarns

It is evident from table 3 that yarn hairiness was highest in case of yarn with 60% silk : 40 % viscose blend (11.29/ km). On the second was yarn with 40% mulberry silk: 60% viscose blendwith a hairiness value of 10.58/ km. The yarn with 50% mulberry silk: 50% viscose blendwas found to have least amount of hairiness with a mean value of 10.83/ km. It can be observed in findings of unevenness percentage, imperfections decrease with decline in silk fibre content, however, value of hairiness rises a little in case of yarn with 40% mulberry silk: 60% viscose blend.

Table 4 Physical properties of blended yarns (20 Nm)

Physical parameters	Proportions			CD Overall CV %
	60% mulberry silk: 40% viscose	50% mulberry silk: 50% viscose	40% mulberry silk: 60% viscose	
Yarn unevenness				
U % CV %	29.5[c]± 0.241 1.825	28.12[b]± 0.124 0.987	24.94[a]± 0.550 4.932	1.091 2.877
Thin -50 %/ km CV %	1865[c]± 1.581 0.190	1354[b]± 3.564 0.589	1156[a]± 0.707 0.137	7.053 0.351
Thick + 50 %/ km CV %	4308[c]± 6.285 0.326	3453[a]± 1.789 0.116	3364[b]± 3.768 0.250	13.427 0/263
Neps + 200 %/ km CV %	7660[c]± 13.344 0.390	5584[b]± 8.376 0.335	5544[a]± 8.739 0.352	35.331 0.409
Hairiness (-)/km CV %	10.23[c] ± 0.064 1.075	10.18[b]± 0.076 1.288	9.72[a]± 0.064 1.149	0.292 2.112

[a,b,c] Significant at 5 % level of significance, same alphabet= no significant difference, different alphabet= significant difference, CD= Critical difference, NS= Not significant

5.3 Yarn unevenness for 20 Nm yarns

It is evident from table 4 that highest U % was shown by yarn blended with 60% mulberry silk: 40% viscose, with a mean value of 29.5 ± 0.241 per cent. The yarn blended using50% mulberry silk: 50% viscose exhibited U % of 28.12 ± 0.124 per cent, followed by yarn with 40% mulberry silk: 60% viscose blend which showed mean value of 24.94 ± 0.550 per cent. A significant difference ($p \leq .05$) was observed among all the three blends. This was due to usage of silk waste fibre during blending, which was uneven and irregular at places.

Thin places (-50%) Maximum thin places were noticed in yarn using of 60% mulberry silk: 40% viscose (1865 ± 1.581 %/ km) blend. The value decreased significantly ($p \leq .05$) with decline in silk component. Thin places for yarn blended using50% mulberry silk: 50% viscose, were found to be 1354 ± 3.564 %/ km. The lowest numbers of thin places were calculated for40% mulberry silk: 60% viscose blended yarn with mean value of 1354 ± 3.564%per km.

Thick places (-50%) The data pertaining to thick places in the blended yarn depicted similar significant ($p \leq .05$) decline in thick places with decrease in ratio of silk fibre. Highest value was achieved by yarn with 60% mulberry silk: 40% viscose (4308 ± 6.285% / km) blend. Thick places of 3453 ± 1.789 % per km were found in yarn with50% mulberry silk: 50% viscose blend and least number of thick places (3364 ± 3.768 %per km) were depicted by yarn with40% mulberry silk: 60% viscose blend.

Neps +200% per km From table 4 it can be observed that number of neps were found significantly high ($p \leq .05$) in case of yarn with 60% mulberry silk: 40% viscose blend (7660 ± 13.344per km) in comparison to 5544 ± 8.739 per km for yarns with 40% mulberry silk: 60% viscose and 5584 ± 8.376 per km of yarn with 50% mulberry silk: 50% viscose blends. The reason for this significant drop in yarn with 50% mulberry silk: 50% viscose blend and yarn with 40% mulberry silk: 60% viscose blend is decrease in silk proportion. Since silk waste fibre was used, more number of neps were recorded in the blend where silk component was present in higher quantity.

It is clear from the results of yarn unevenness that value of yarn unevenness dropped with decline in silk component. Similar trend has been observed for all the parameters. Mulberry silk waste fibres had more number of irregularities. Also the coefficient of variation of fibre diameter clearly reveals that there was more variation in diameter of the mulberry silk waste. The results are in line with the findings of Gahlot and Pant (2011), in which the irregularities decreased with rise in viscose content and a decline in silk component.

5.4 Yarn hairiness for 20 Nm yarns

It is evident from table 4 that yarn hairiness was highest in case of yarn with 60% mulberry silk: 40% viscose (10.23/ km) blend. The yarn blended with 50% mulberry silk: 50% viscose had hairiness value of 10.18 / km. The yarn with 40% mulberry silk: 60% viscose blend showed least amount of hairiness with a mean value of 9.72 / km. A significant difference was noticed among all the blends at 95 % confidence level. The results depicted that hairiness figures decrease with decline in silk fibre content.

5.5 Fabric development

Before initiation of the knitting process, blended yarns were examined and compared on the basis of unevenness parameters *viz.* yarn neps (+200 %) and hairiness. For development of knitted fabrics, yarns in suitable proportions were selected after comparing yarn properties in both the counts. Yarns in proportions of 50% mulberry silk: 50% viscose and 40% mulberry silk: 60% viscose in both the yarns counts were found having lesser unevenness, therefore were selected for development of knitted fabrics.

5.6 Coding of developed fabric proportions

Developed knitted fabrics were assigned codes for ease of discussion and understanding. Fabric knitted in 50% mulberry silk: 50% viscose yarn and 15 Nm count was called S1 and fabric made in 40% mulberry silk: 60% viscose in the same count was assigned code S3. In case of 20 Nm yarn count, codes S2 and S4 were the assigned to fabrics with 50% mulberry silk: 50% viscose and 40% mulberry silk: 60% viscose respectively.

Table 5 Pilling properties of blended knitted fabrics

Physical parameters	S_1 50% mulberry silk: 50% viscose	S_2 50% mulberry silk: 50% viscose	S_3 40% mulberry silk: 60% viscose	S_4 40% mulberry silk: 60% viscose	t-value
Pilling resistance (Grade)	$3.000^{b} \pm 0.0$	$3.167^{b} \pm 0.167$	$3.367^{b} \pm 0.333$	$4.012^{a} \pm 0.167$	0.447
Pilling density (count/cm^2)	$2.800^{b} \pm 0.0$	$2.201^{a} \pm 0.145$	$2.812^{b} \pm 0.012$	$2.000^{a} \pm 0.120$	0.442

^{abc}Significant, t value = calculated value of t, for differences of two means at two tail and 5 per cent level of significance

5.7 Pilling resistance

Mean values for pilling resistance of all the fabrics are shown in table 5. It can be observed that fabric S_4 showed highest grade for pilling with significant difference with other blends.

5.7.1 Prediction of pilling resistance

For prediction of pilling grade, its correlation with various independent variables such as presence of silk fibre content, yarn unevenness and yarn hairiness, was analyzed.

5.7.2 The correlation between pilling resistance and silk fibre content

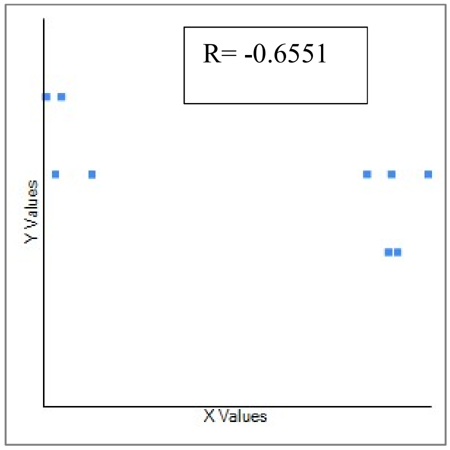

Figure 1 Correlation between silk fibre content and pilling resistance

Since silk waste fibres have been utilized for the study, they may lead to higher pilling tendencies in comparison to viscose fibre. Shanbhag (2009) indicated that silk waste fibres when utilized in higher quantities may become a cause of entanglement of fibres on fabric surface, which is why correlation between pilling resistance and silk fibre content were calculated and shown in figure 1. X values indicate silk fibre content whereas Y fibres show pilling grades in this case. This came out a moderate negative correlation, which means that high X variable that is if quantity of silk fibres with low Y variable scores that is pilling resistance (and vice versa).

5.7.3 The correlation between pilling resistance and yarn unevenness

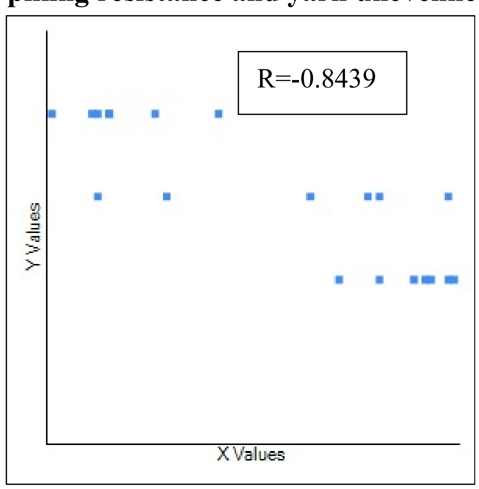

Figure 2 Correlation between yarn unevenness and pilling resistance

Correlation between yarn unevenness and pilling resistance was calculated and shown in figure 2. X values indicate yarn unevenness whereas Y fibres are indicative of pilling resistance. The findings show that there was a strong negative correlation, which means that high X variable scores that is unevenness in yarns go with low Y variable scores (pilling performance) and vice versa. (Kayseri and Kirtay 2015) concluded after their study on prediction of pilling tendencies that while fuzz formation occurs intensively, some of these fuzzes aggregate and pills are created on the fabric surface. The value of R in present calculation was -0.8439.

5.7.4 The correlation between pilling resistance and yarn hairiness

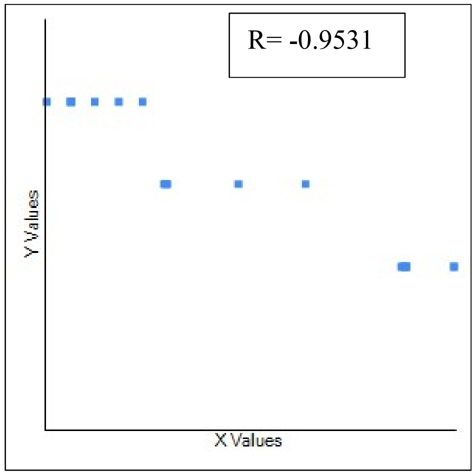

Figure 3 Correlation between yarn hairiness and pilling resistance

Correlation between yarn hairiness and pilling resistance was calculated and shown in figure 3. This came out to be a strong negative correlation, which means that yarn hairiness when increased, the values of pilling resistance will reduce. Beltran et al (2007) during their study, suggested that a relatively large reduction in yarn hairiness was needed to achieve a moderate improvement in fabric pilling.

5.8 Pilling density

Mean values for pilling grade of all the fabrics are shown in table 5. It can be observed that fabric S_4 showed lowest value for pilling density, however fabric S_2 also showed similar results with pilling density very close to that of fabric S_4. Significant difference was noted with other two blends.

5.8.1 Prediction of pilling density

For prediction of pilling density, its correlation with various independent variables such as presence of silk fibre content, yarn unevenness and yarn hairiness, was analyzed.

5.8.2 The correlation between pilling resistance and silk fibre content

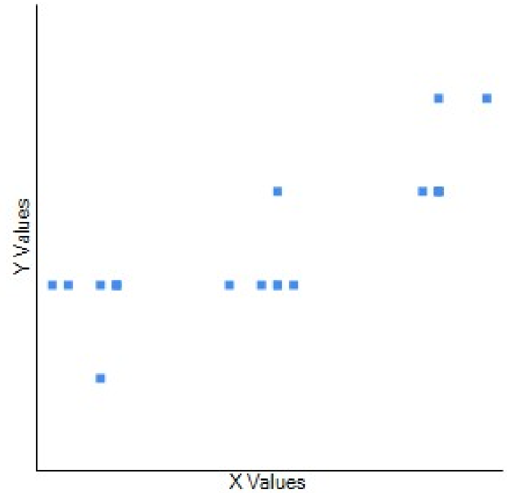

Figure 4 Correlation between pilling density and silk fibre content

A strong positive correlation was found between the silk fibre content and pilling density, however since higher value in pilling density is undesired it will be considered as strong negative correlation with R value -0.8189. As mentioned by Murry (2016) in her study, since silk fibre is a continuous fibre, it has more tiny ends , which get tangled together and create pills. It happens usually when the fabric is rubbed or abraded somehow.

5.8.3 The correlation between pilling density with yarn unevenness

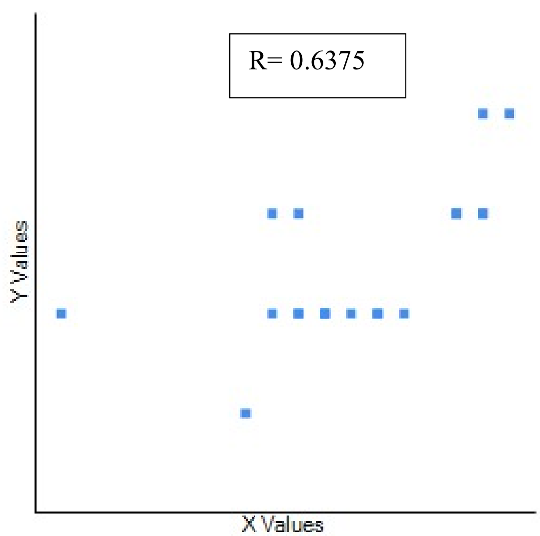

Figure 5 Correlation between pilling density and yarn unevenness

The relationship between yarn unevenness and pilling density has been found moderatly positive, which means there is a tendency for high X variable scores go with high Y variable scores (and vice versa). Wahid (2015)

5.7.4 The correlation between pilling density and yarn hairiness

A strong positive correlation has been noticed between pilling density and yarn hairiness. The value of R has been found as 0.9188. Beltran et al (2007) concluded during their study that the nature of yarn hairiness was also a key factor in influencing fabric pilling propensity.

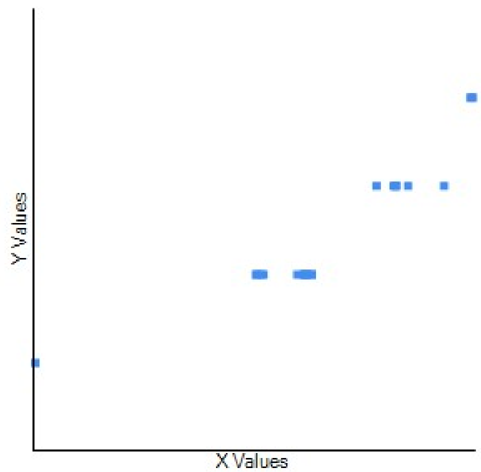

Figure 6 Correlation between pilling density and yarn hairiness

6. Conclusion

Pill formation on fabrics may cause decrement in usage life and quality of fabric. Also, it ruins the appearance of the garment. Objective evaluation of pilling in the present study has brought about following findings. At the stage of yarn, least unevenness was noticed in yarns with 40% mulberry silk: 60% viscose as compared to other blends in both the yarn counts (15 Nm and 20 Nm). Similar was the result with the findings of yarn hairiness, least hairiness was computed for yarn with 40% mulberry silk 60%: viscose. Based on the results yarns in proportions of 50% mulberry silk: 50% viscose and 40% mulberry silk: 60% viscose in both the yarns counts were found suitable for development of knitted fabrics. At the stage of fabric, pilling resistance and pilling density of all the four knitted fabric was analyzed. Knitted fabric with 40% mulberry silk: 60% viscose, in 20 Nm showed highest grade for pilling having significant difference with other blends. Following the similar trend, pilling density was found minimum in case of 40% mulberry silk: 60% viscose, in 20 Nm. A mix and balance of available figures assert that knitted fabric blended in 40% mulberry silk: 60% viscose in 20 Nm yarn count is least susceptible to pilling and is most suitable out of all the fabrics for clothing construction. Correlation between pilling resistance and pilling density with silk fibre content, yarn unevenness and yarn hairiness exhibit that fabric knitted by using lesser amount of silk fibre and finer yarn count shows better pilling performance and is found better for apparel use.

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