Effect of Different Blend Ratios of Natural Fibers on Yarn Properties

Rakhsahan Ahsan¹, Asma Akmal²

¹Assistant Professor/Ph.D Scholar, Department of Home Economics Clothing and Textiles, Punjab University, Lahore, Pakistan.
²Assistant Professor, Govt. Islamia Graduate College, Lahore Cantt.

Received: 08 March 2022 Published: 30 June 2022

Abstract:
Yarn construction is an important attribute in fabric construction and end use performance of fabric. The purpose of this study was to investigate the effect of different blend ratio of natural fibers, on yarn properties. Four different fibers such as Bamboo regenerated fiber, cotton, flax, and hemp were used at different blend ratios to manufacture ring spun 16/1 yarns with TM of 4.0. Blend ratios of bamboo regenerated fiber was kept 100%, 90 %, 80 % and 70 % while blend ratios of cotton, flax and hemp were adjusted at 10 %, 20 % and 30 %. Thus, total of ten yarn samples were prepared for this study. Different properties of these yarns such as linear density, lea strength, clsap, tensile properties, unevenness, imperfections, and hairiness, were determined as per standard test methods. Analysis of the collected data shows a significant effect of blend change on all yarn properties. It may be concluded that blends of bamboo regenerated fibers with cotton displayed best results as compared to blends with flax and hemp. Another trend may also be revealed that yarn quality improved as ratio of cotton changed from 10 % to 30 % while degraded as ratio of flax and hemp is changed from 10 % to 30%.

Keywords: Fiber, Blend ratio, Yarn properties.

DOI Number: https://doi.org/10.52700/jn.v2i2.57

© 2022 The authors. Published by The Women University Multan. This is an open access article under the Creative Commons Attributions-NonCommercial 4.0.

Introduction:
Since the beginning of time, textiles have been significant in human history. The simplest type of textile is fabric, which is created from fibre and yarn (Jahan 2017). According to Faulkner, W. B., Hequet, E. F., Wanjura, and Boman (2012), fibre qualities are crucial in determining yarn quality metrics and fabric constructions. Bamboo fibres' physical and chemical characteristics are quite similar to those of viscose. Additionally, bamboo fibre quickly absorbs and dries off sweat. The wearer is kept dry and comfortable for a long time because to its exceptional breathability. It has a 3–4 times greater absorption capacity than cotton cloth. According to Okubo, Fujii, and Yamamoto (O.), bamboo fibre is also inherently cool to the touch (2004).
Due to its numerous qualities and ability to meet an increasing demand from both home and commercial applications, cotton fibre is the most commonly used natural fabric for garments (Latif et al. 2018). In contrast to other fibre plants, hemp is thought to be an active and significant medical plant, which is why it isn’t used in experiments as frequently (Benet 1975). In ancient Ethiopia and ancient Egypt, flax was commonly cultivated. According to numerous papers (kenaf genetics and agronomy by Dr. Cook, USDA, and A. Scott, Rio Farms), the use of flax fibre in the construction of cloth dates back to the Neolithic era in northern Europe. There are several structural factors that affect the performance characteristics of fabric, including the type of fibre and blend, yarn linear density, count, weave patterns, weight, and thickness (Hussain et al. 2010;)

The study on spinnability and tensile evaluation of flax/cotton blends was looked at by Lawal, A. S. Blends of flax and cotton that have a higher percentage of flax were discovered to be particularly difficult to spin. By reducing the flax aspect to no more than 50 percent, spinnability can be increased. The 10/90 flax/cotton combination yarn has the best tenacity and elongation at break of all three blends that have been spinnable, whereas the 50/50 flax/cotton mixture yarn has the worst. The reason for the poor tensile characteristics of 50/50 flax/cotton combination yarns was that they were most likely caused by the flax fibres’ characteristics (Lawal, A. S. (2011).

This study was carried out to look into the impact of fabric count on the tensile strength of fabrics made of polyester and cotton blends. In this investigation, two sets of fabrics were created: one with simultaneous increases in pick number and fabric length, and the other with pick number increasing while fabric length remained constant. The impact of the increase in ends and picks was then assessed in quantitative terms. It was determined that increasing fabric length in either one direction or both ways increases a fabric's tensile strength in both directions. However, the relationship between the increase in tensile strength and the fabric's weave is not always linear. The efficiency of converting yarn strength into fabric strength improves with increasing fabric count. Zulfiqar Ali Malik, July 2009.

This study focuses at analysing and assessing the relation among fibre properties, process controlling and yarn properties. The test results have highlighted the relation between cotton fibre qualities, slivers and yarn properties, and the performance of thin cotton compact yarns. The findings demonstrate that as yarn count grows, the degree of yarn inequity increases, while according to the results of the unevenness, there was an opposite situation in the tensile
strength values. As it is clear from the results that yarn toughness rises as fibre length, homogeneity, and strength, whereas it falls with the presence of debris, short fibre index, and neps. The yarns' extensibility increases as fibre fineness and moisture content rise, and decrease as fibre length falls index within the fibre mixture. However, as the yarns age, their unevenness and hairiness worsen. In the blend, there is an increase in garbage, short fibre index, and neps. Additionally, the rise in fibre the yarn's unevenness and hairiness are reduced by its fineness, maturity, length, and homogeneity. Additionally, models of linear regression were developed to calculate the characteristics of yarn from other fibres. It was possible to get parameters and useful estimating models.

The quality characteristics of the bamboo regenerated, and bamboo blends ratios were assessed at yarn development stage and examined in a unique way from previous research.

**Materials and methods:**

In this study, four different fibers such as bamboo regenerated fiber, cotton, flax, and hemp fibers were used to make the yarns. Bamboo regenerated fiber blend ratios were selected at 100%, 90%, 80% and 70% while of cotton, flax and hemp were adjusted at 10%, 20% and 30%. Blending was done before starting the process of spinning by weighing and mixing the related components through stack mixing method. Yarns of 16/1 were made using ring spinning technique with TM of 4.0. Spinning processes consist of blow room, card, drawing, simplex, ring and Auto cone machines which were adjusted as per specifications of the fiber blends. Different specifications of bamboo, cotton, flax, and hemp are given here in Tables 1 and 2.
Table 1: Specifications of cotton

| S. No | Attributes                     | Values      | S. No | Attributes                        | Values  |
|-------|-------------------------------|-------------|-------|-----------------------------------|---------|
| 1     | Length (UHML) mm              | 28.194      | 8     | Short Fiber Content (%)           | 18.0    |
| 2     | Uniformity Index              | 82.5        | 9     | Immature Fiber Content (%)        | 5.8     |
| 3     | Short Fiber Index             | 10.3        | 10    | Maturity Ratio                    | 0.95    |
| 4     | Bundle fiber Strength (g/Tex), (g/denier) | 31.7 (3.52 ) | 11    | Neps/gm                           | 204     |
| 5     | Mike (µg/inch) (denier)       | 4.3 (1.53)  | 12    | Trash (%)                         | 6.20    |
| 6     | Reflectance degree (Rd)       | 73.0        | 13    | Spinning Consistency Index        | 133     |
| 7     | Yellowness (+b)               | 9.3         | 14    | Moisture (%)                      | 8.5 %   |

Table 2: Specifications of bamboo, flax, and hemp fibers

| S. No | Attributes                     | Bamboo fibers specs | Flaxfibers specs | Hempfibers specs |
|-------|-------------------------------|---------------------|------------------|------------------|
| 1     | Staple length (mm)            | 38                  | 15-50            | 15-50            |
| 2     | Fiber fineness (denier)       | 1.2                 | 6.0              | 16.0             |
| 3     | Tenacity (g/denier)           | 2.5                 | 5.2              | 6.4              |
| 4     | Elongation (%)                | 23.8                | 3.5              | 2.0              |
| 5     | Moisture (%)                  | 13.0                | 12.0             | 12.0             |

Thus, one yarn of 100% bamboo, three yarns of bamboo and cotton blends, three yarns of bamboo and flax blends and three yarns of bamboo and hemp blends were manufactured. In this way, total of ten yarns of 16/1 were made in yarn manufacturing labs of National Textile University Faisalabad. Different properties of these yarns such, yarn count (linear density), lea strength, CLSP, CVm, Imperfections such as thin places (-50 %), thick places (+50%), neps (+200%), hairiness, breaking force, tenacity, and elongation were determined as per standard test methods given in
Table 3: Data collected from this investigation are consolidated here in Table 4.

| Test Name                                      | Standards     | Instrument used                      |
|------------------------------------------------|---------------|--------------------------------------|
| Linear density by lea method                   | ASTM D 1059   | Wrapping reel and weighing scale     |
| Lea strength                                   | ASTM D 1578   | Lea strength tester                  |
| Tensile properties of single yarn              | ASTM D 2256   | Uster Tensorapid                     |
| Yarn Unevenness, Imperfections, and hairiness | ASTM D 1425   | Uster Tester 4                       |

Table 4: Average properties of yarns manufactured for this study

| Attributes                  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Blend ratio (B)             | B   | B/C | B/C | B/C | B/F | B/F | B/F | B/H | B/H | B/H |
| Count (Ne)                  | 16.45 | 16.34 | 16.12 | 16.24 | 16.35 | 16.44 | 16.8 | 16.03 | 16.22 | 16.45 |
| Lea strength (lbs)          | 132.6 | 141.4 | 142 | 159.2 | 145.8 | 122 | 109.4 | 144.8 | 121.4 | 98.6 |
| C.V %                       | 3.31 | 4.73 | 2.98 | 1.20 | 2.49 | 3.42 | 1.89 | 2.20 | 2.37 | 3.69 |
| CLSP                        | 2181 | 2310 | 2289 | 2585 | 2312 | 2002 | 1837 | 2318 | 1969 | 1622 |
| CV_m (%)                    | 11.94 | 11.38 | 11.71 | 11.93 | 13.42 | 16.55 | 19.17 | 15.59 | 19.39 | 23.08 |
| Thin places (-50%)          | 1.5 | 0.5 | 1.0 | 2.0 | 7.5 | 45.5 | 210 | 18 | 150.5 | 604.5 |
| Thick places (+50%)         | 5.5 | 3.5 | 3.5 | 7.5 | 70 | 351 | 762.5 | 315.5 | 938 | 1814 |
| Neps (+200 %)               | 15 | 7.5 | 10.5 | 9.5 | 137.5 | 782.5 | 1692 | 665.5 | 4976 | 3769 |
| IPI (numbers)               | 22 | 11.5 | 15 | 19 | 215 | 1179 | 2664 | 999 | 6064 | 6187 |
| Hairiness (-)               | 7.24 | 6.43 | 6.22 | 6.56 | 6.16 | 7.66 | 7.94 | 6.61 | 7.31 | 7.84 |
| Breaking force (cN)         | 461.3 | 490 | 544.8 | 547.4 | 565.8 | 427.7 | 445.7 | 534.5 | 497.6 | 375.4 |
| C.V %                       | 8.24 | 7.76 | 6.97 | 6.35 | 8.25 | 9.43 | 11.33 | 8.73 | 12.92 | 14.78 |
| Tenacity (cN/Tex)           | 12.5 | 13.28 | 14.76 | 14.83 | 15.33 | 12.81 | 12.08 | 14.48 | 13.48 | 10.17 |
| Elongation (%)              | 7.27 | 9.21 | 10.4 | 11.61 | 13.4 | 9.41 | 9.45 | 12.8 | 10.82 | 7.26 |
| C.V %                       | 18.7 | 21.3 | 13.76 | 7.29 | 8.56 | 12.71 | 21.83 | 11.95 | 19.33 | 23.22 |

In Table 4 of yarn properties, CLSP is the product of count and lea strength, IPI is the sum of thin places, thick places and neps while tenacity is the ratio of breaking strength and yarn fineness (Tex count). Here IPI stands for yarn imperfections.
Results and discussion:

Yarn properties given in Table 4 can be compared in four groups of yarns. 1st group consists of only one yarn of 100 % bamboo which is the reference for all other yarns. Other three groups are the blends of bamboo with cotton, flax, and hemp respectively. So, these three groups may be compared with each other and also with reference sample of 100 % bamboo. So, to find the effect of different fiber blends, different yarn properties such as CLSP, CV_m, IPI, hairiness, tenacity, and elongation are plotted using Excel software and are given in Figures 1 to 6.

![Bar chart showing comparison of yarn CLSP for different fiber blends](http://jn.wum.edu.pk)

**Figure 1:** Comparison of yarn CLSP for different fiber blends

Figure 1 shows that CLSP of bamboo/cotton blended yarns is higher than bamboo/flax and bamboo/hemp blends. Even CLSP of bamboo/cotton blended yarns is higher than the reference sample of 100 % bamboo. Cotton fiber is stronger than bamboo and weaker than flax and hemp. However, cotton is much finer fiber than flax and hemp. Thus, there are more fibers in yarn cross section in bamboo/cotton blend as compared to bamboo/flax and bamboo/hemp blend. Moreover, elongation of flax and hemp fibers is too low which also contribute to reduce the CLSP. Thus, it can be said that overall bamboo/cotton blend is good regarding yarn CLSP as compared to other blends or 100 % bamboo yarn CLSP.
Figure 2: Comparison of yarn CV\textsubscript{m} for different fiber blends

Figure 2 shows that coefficient of mass variation (CV\textsubscript{m}) of bamboo/cotton blended yarns is lower/good than bamboo/flax and bamboo/hemp blends. Even CV\textsubscript{m} of bamboo/cotton blended yarns is good than the reference sample of 100 % bamboo. Cotton fiber is stronger than bamboo and thus support the weak bamboo fiber in blend and reduce its damage in swear mechanical action of carding. Cotton fiber fineness is also near to bamboo, so these fibers are good match. Hence provide less mass variation in yarn when compared with bamboo yarn and bamboo blends with flax and hemp. Bamboo denier is much low as compared to flax and hemp. So, their blends are not good match with bamboo fibers and hence create more mass variation in yarn.
Figure 3: Comparison of yarn IPI for different fiber blends

Figure 3 shows that yarn imperfections (IPI) of bamboo/cotton blended yarns and 100 % bamboo are less than 50 while of bamboo/flax yarns are 256 to 2664 and of bamboo/hemp yarns are 1019 to 6187. Thus, there is a big difference in yarn imperfections between these groups of yarns which reveals that there is a damage of fiber in the process and uncontrol material flow in drafting system. These issues are due to stiff nature and high denier of flax and hemp fibers. These fibers are not fully pliable due to coarser and stiff nature.

Figure 4: Comparison of yarn hairiness for different fiber blends

http://jn.wum.edu.pk
Figure 4 shows that yarn hairiness (H) of bamboo/cotton blended yarns is less than bamboo/flax, bamboo/hemp as well as 100 % bamboo yarns. Cotton fiber is stronger than bamboo and its fineness is near to bamboo, elongation is higher than flax and hemp, these properties save it during process while other fibers are damaged and broken during severe process of carding and show high hairiness as their %age increased in the blend.

![Graph showing yarn tenacity comparison](http://jn.wum.edu.pk)

**Figure 5: Comparison of yarn tenacity for different fiber blends**

Figure 5 shows that overall tenacity of bamboo/cotton blended yarns is higher than bamboo/flax and bamboo/hemp blends. Even tenacity of bamboo/cotton blended yarns is higher than the reference sample of 100 % bamboo. Cotton fiber is stronger than bamboo and weaker than flax and hemp. However, cotton is much finer fiber than flax and hemp. Thus, there are more fibers in yarn cross section in bamboo/cotton blend as compared to bamboo/flax and bamboo/hemp blend. Moreover, elongation of flax and hemp fibers is too low which also contribute to reduce the tenacity. Thus, it can be said that overall bamboo/cotton blend is good regarding yarn tenacity as compared to other blends or 100 % bamboo yarn tenacity.

Figure 6 shows that overall elongation of bamboo/cotton blended yarns is higher than bamboo/flax and bamboo/hemp blends. Even elongation of bamboo/cotton blended yarns is higher than the
reference sample of 100 % bamboo. Cotton fiber is stronger than bamboo and weaker than flax and hemp. However, cotton is much finer fiber than flax and hemp. Thus, there are more fibers in yarn cross section in bamboo/cotton blend as compared to bamboo/flax and bamboo/hemp blend. Moreover, elongation of flax and hemp fibers is too low which also contribute to reduce the overall yarn elongation. Thus, it can be said that overall bamboo/cotton blend is good regarding yarn elongation as compared to other blends or 100 % bamboo yarn tenacity.

![Comparison of Elongation](image)

**Figure 6:** Comparison of yarn elongation for different fiber blends

Figures 1 to 6 show that yarn properties differ not only between the groups but also within the groups which reveals that yarn properties vary as blending fiber is changed from cotton to flax or flax to hemp. Similarly, yarn properties vary as blending fiber %age is changed from 10 to 20 and 20 to 30. To confirm whether this difference in properties is statistically significant or not, ANOVA analysis may be conducted. There were 5 individual values for CLSP, CVm, IPI, and hairiness while 10 individual values for tenacity and elongation. So, groupwise single values of all plotted yarn properties were fed in the sheet of Minitab software and conduct the ANOVA analysis. Output of the analysis is given here in Tables 5.

**Table 5:** Analysis of variance for different yarn properties

| Analysis of Variance for yarn CLSP |
|-----------------------------------|
| Source | DF | Adj SS | Adj MS | F-Value | P-Value |
| 100%Bamboo | | | | | |
| Bamboo/Cotton | | | | | |
| Bamboo/Flax | | | | | |
| Bamboo/Hemp | | | | | |

http://jn.wum.edu.pk
| Source       | DF | Adj SS   | Adj MS   | F-Value | P-Value |
|-------------|----|----------|----------|---------|---------|
| Experiment  | 9  | 179663087| 19962565 | 762.79  | 0.000   |
| Error       | 40 | 1046822  | 26171    |         |         |
| Total       | 49 | 180709909|          |         |         |

Analysis of Variance for yarn IPI

| Source       | DF | Adj SS  | Adj MS  | F-Value | P-Value |
|-------------|----|---------|---------|---------|---------|
| Experiment  | 9  | 16.800  | 1.8667  | 17.91   | 0.000   |
| Error       | 40 | 4.170   | 0.1043  |         |         |
| Total       | 49 | 20.971  |         |         |         |

Analysis of Variance for yarn hairiness

| Source       | DF | Adj SS   | Adj MS   | F-Value | P-Value |
|-------------|----|----------|----------|---------|---------|
| Experiment  | 9  | 740.241  | 82.2490  | 719.84  | 0.000   |
| Error       | 40 | 4.570    | 0.1143   |         |         |
| Total       | 49 | 744.812  |          |         |         |

Analysis of Variance for yarn tenacity

| Source       | DF | Adj SS  | Adj MS  | F-Value | P-Value |
|-------------|----|---------|---------|---------|---------|
| Experiments | 9  | 202.6   | 22.517  | 15.00   | 0.000   |
| Error       | 90 | 135.1   | 1.501   |         |         |
| Total       | 99 | 337.8   |         |         |         |

Analysis of Variance for yarn elongation

| Source    | DF | Adj SS | Adj MS | F-Value | P-Value |
|-----------|----|--------|--------|---------|---------|

http://jn.wum.edu.pk
The value of P in all cases of yarn properties is less than 0.05 so it may be said that difference in yarn properties between these groups is highly significant. So, there is a significant effect when cotton is added in bamboo, and cotton is replaced with flax and then flax with hemp fibers. This effect is due to difference in their basic properties such as staple length, fineness, strength and elongation and their behavior in the process.

Conclusions:

Different yarn properties vary as blending material of cotton, flax and hemp are added in the bamboo regenerated fiber separately. This difference in yarn properties of bamboo/cotton, bamboo/flax and bamboo/hemp blend groups is highly significant as values of P for yarn CLSP, CV_m, IPI, Hairiness, tenacity and elongation are 0.000 which is less than 0.05 keeping in view the 95 % confidence limits. Comparative analysis show that quality of bamboo/cotton blended yarns is better than yarns of other blend groups. Further, yarn properties improved as cotton %age in bamboo/cotton blend is increased from 10 to 20 and then 20 to 30 %.

References

Jahan, I. (2017). Effect of fabric structure on the mechanical properties of woven fabrics. Advance Research in Textile Engineering, 2(2), 1018-2.

Faulkner, W. B., Hequet, E. F., Wanjura, J., & Boman, R. (2012). Relationships of cotton fiber properties to ring-spun yarn quality on selected High Plains cottons. Textile Research Journal, 82(4), 400-414.

Okubo, K., Fujii, T., & Yamamoto, Y. (2004). Development of bamboo-based polymer composites and their mechanical properties. Composites Part A: Applied science and manufacturing, 35(3), 377-383.

Basit, A., Latif, W., Baig, S. A., Rehman, A., Hashim, M., & REHMAN, M. Z. U. (2018). The mechanical and comfort properties of viscose with cotton and regenerated fibers blended woven fabrics. Materials Science, 24(2), 230-235.
Benet, S. (1975). Early Diffusion and Folk Uses of Hemp. Cannabis and culture, 39.

Numerous reports (kenaf genetics and agronomy by Dr. Cook, USDA and A. Scott, Rio Farms).

Hussain, T., Malik, Z. A., & Tanwari, A. (2010). Prediction of tensile strength of polyester/cotton blended woven fabrics.

Lawal, A. S. (2011). Spinnability and tensile evaluation of flax/cotton blends. Pakistan Textile Journal, 60(2).

Zulfiqar Ali Malik, Anwaruddin Tanwari, Hafizurrehman Sheikh, Received on 16.03.2009 Accepted on 13.08.2009. Influence of plain and twill (3/1) weave design on the tensile strength of pc blended fabrics.