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Impact of Hollow Cellulosic Fiber-Based Polyester / Cotton / Bamboo Hybrid Composites on Physical and Some Comfort Properties

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Abstract

Two blends of fibers were delivered in the presence and absence of Chorisia hollow fibers. The first blend was produced using the ratio of 22, 28, 22, and 28%, cotton and polyester wastes, raw bamboo, and Chorisia, respectively. The second blend was 33.33, 33.33, and 33.33 % cotton and polyester wastes by open-end spinning. Then, at that point, six woven textiles were produced by those yarns with satin structure. The effect of Chorisia hollow fibers on the properties of the produced fabrics had been investigated. The results showed that the presence of Chorisia hollow fibers with the blends has a positive impact on some properties of the produced yarns and fabrics, where it increased tenacity and elongation and decreased the unevenness% (U%) of yarns, increased shrinkage and bending length all in both weft and warps direction and increased thickness, decreased pilling, air and water permeability, comfort, abrasion, and tear strength compared to our previous investigation. This could regenerate products with a high-value application and having a high mechanical performance rather than the current items from post-industrial fibrous wastes.
Keywords: Chorisia hollow fibers; fiber wastes; raw bamboo; yarn quality; high-value application

1. Introduction

Hollow-based fibers are considered single-cell cellulosic fiber with the most significant hollowness level [80–90%] among the natural fibers[1,2]. This hollow structure empowers it to secure a porosity of over 80%. However, some of the specific features of hollow -based fiber, as it is so short and light cutoff its application as a textile raw material for a long time[3,4].

Bamboo is one of the most important plant fiber that can benefit designing and advancement polymer composites[5]. It has 60% cellulose with highly satisfied lignin, and its microfibrillar angle is 2–10˚, which is generally little. This trademark property has made bamboo fiber as fiber for reinforcement of an assortment of lattices[6,7]. Bamboo fibers were extracted from raw bamboo trees by steam explosion technique involving alkaline treatment for the development of eco-composites and assessed mechanical properties of bamboo fiber reinforced polymer composites[8,9]. This kind of fiber has been demonstrated to have a thinness and whiteness degree like standard finely bleached viscose, as well as strong durability, stability, and tenacity[10,11]. It has extensively more noteworthy moisture absorption, and ventilation since the cross-section of the fiber is

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packed with numerous micro-gaps and micro-holes[9].

Chorisis spp. is an Egyptian agricultural product obtained from the fruits of the Chorisia tree and was planted in different places in Egypt, Aswan, Alexandria, Monufia and Beni-suef that produces Chorisia hollow fibers, for example, kapok trees in Asia which often called „bombax cotton", their family is Bom-bacaceae [4,12,13]. Chorisis spp. fibers are profoundly lignified organic seed fibers and comprise cellulose, lignin and xylan at different ratios [14]. The chemical composition of the fiber varies in various reports, as indicated by kapok sources and handling strategies[15]. Pure hollow- based fibers like Bombax, kapok and Chorisia SPP. cannot spin separately because of short length, low density and their exceptionally smooth surface[4,16]. However, they can effectively blend with cotton and polyester fibers to form yarns.

Sunmonu and his co-workers[1] prevailed concerning the spinning of kapok-cotton blended yarn with blending ratios of 60:40 and 50:50 utilizing rotor spinning technology. The blending of hollow fiber with cotton, rayon, and other cellulosic fibers at various blending ratios utilizing rotor and traditional spinning techniques has also been investigated[17]. Outcomes revealed that the blended yarn could be used as a weft with a possible blending ratio of up to 50%. Sun's and his laborers detailed that the evenness of kapok blended yarn could satisfy the assembling need when the content of kapok fibers in the blending yarn was less than 50%[18]. Besides, kapok/cotton blended fiber appears to have comparable moisture permeability with pure cotton. In any case, the air permeability is decreased, and the warmth retention and water vapor transmission properties are upgraded owing to the exceptionally permeable construction of the kapok fiber[19–21]. It was reported that the moderate alkali treatment for kapok fiber, could be decreased the crystallinity of the blended yarns contrasted with cotton fiber[22,23]. Inserting kapok fiber into the low-melting fiber can further develop the buoyancy behavior of kapok fiber assemblies which acquire compression resistance and give a better buoyancy figure[2,24]. Additionally, the blending of kapok fiber with polypropylene fiber for advancing of sound-absorptive non-woven materials comes about in kapok fiber composites and shows very good sound retention behavior within the frequency range of 250–2000 Hz[25]. Hybridization of kapok fiber into glass and sisal fabrics in a polyester matrix significantly increased hybrid composites' effect strength significantly by 34%[26] . Generally, kapok fibers have been broadly investigated in literature as a weft or blend with pure raw materials, with no fiber wastes.

Our research team has recently produced yarns by blending Egyptian Chorisia Spp. with cotton and polyester wastes at different ratios, using 40% Chorisia, 30% cotton wastes, and 30% polyester wastes with a little long fiber content in the blends. The presence of Chorisia fibers in the blend prompts a lower tensile strength, yarn quality, and regularity due to the presence of a percent of thin places and an increase in the thick places and neps[4,12,13]. However, Chorisia fibers have led to the improvement of yarn elongation. Because of this study, Chorisia fibers can save half the amount of cotton in the event of utilizing pure cotton and 100% of cotton in case of using cotton wastes. We also detailed the production of the woven fabrics from the yarns mentioned above at different weft counts. Unfortunately, the thick counts of produced fabrics from the blending Chorisia fibers acquired higher tensile strength than the thin counts. Thus, they impeded their further application and were unfit to meet textiles' wearability and comfort requirements [27,28].

The aim of this work is the production of a blend from cotton and polyester wastes, Chorisia fibers, and raw bamboo to obtain better fabrics' properties other than our previous study. The main other objective is to find whether the presence of Chorisia fibers is influential and has a positive effect on the fabrics' physical and some comfort properties.

2. Materials and methods

2.1. Materials

Egyptian Chorisia fibers [Figure 1] were collected from Aswan. Separating the seeds from the fibers was done manually and easily. These fibers do not need either the opening or the cleaning processes, unlike any other natural fibers. After that, the Chorisia fibers were blended with the other fibers. Cotton waste, polyester waste, raw bamboo, and Chorisis spp. fibers, with fiber length 1.3, 3.2, 3.8, and 2 cm, respectively, have been used in fiber blending. The source of the wastes was carded cotton (giza 45) and continuous filaments polyester that was opened from the remains of the cone's yarns

2.2. Blended fibers

Two manual blends were formed. The first was 22, 28, 22, and 28% cotton waste, polyester waste, raw bamboo, and Chorisia, respectively. The second was

33.33, 33.33, and 33.33 % cotton waste, polyester waste, and raw bamboo to produce one carded sliver of each blend. The carding machine was fed by the two manual blends through chute feed to produce carded sliver of each blend, each sliver weighs 6 gm/ m. The used carding machine was Rieter, Switzerland C50, speed 80 m/min.

Fig. 1. Egyptian Chorisia raw fibers [4]

2.3. Produced weft yarns

Three different counts were produced from each carded sliver: 4/1, 6/1, and 10/1 Ne with twist factor 6.2 using Open- End machine, Schlafhorst, Germany, Se 11, Speed 50000 turn/min. A number of spindles have been assigned to spinning yarns [Figure 2].

Fig. 2. produced weft yarns at different counts and fiber formulations

2.4. Produced fabrics

Six specimens were produced from both blends using woven construction satin 4 and weft picks 18, 12, 10 /cm for 10/1, 6/1, 4/1 Ne, respectively [Figure 3], using weaving loom, Picanol Optimax 2007, Dobby, Rapier, 20 healds, 21 dent/cm, 2end / dent, 184 fabric width with selvage, speed 400 pick / min.

2.5. Yarn Tests

2.5.1. Yarn evenness

ASTM D1425 for Evenness of Textile Strands using Capacitance Testing Equipment were used for determine thick places, thin places and neps' number using Uster tester apparatus**.**

2.5.2. Tenacity [Kgf/den] and Elongation [%]

Tenacity and elongation of yarns and fabrics were tested according to standards ASTM-D2256 – Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method using Instron Tester.

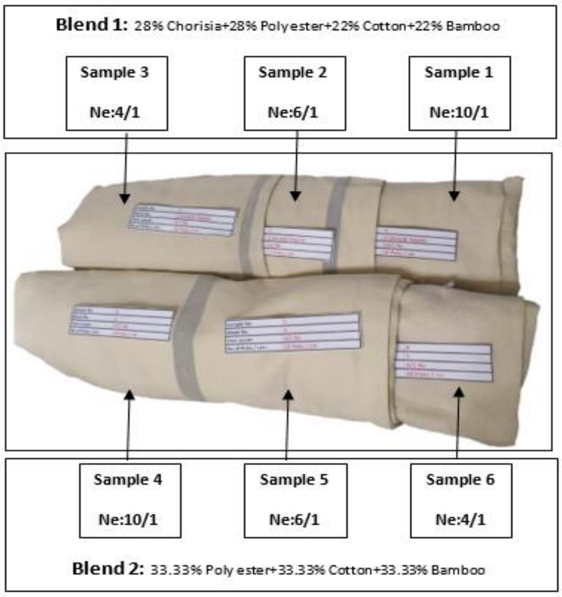

Fig. 3. produced fabric samples from two blends

2.6. Fabric Tests

2.6.1. Thickness [mm]

Using Thickness Gage apparatus according to ASTM standard D 1777-96, an average of fifteen readings were taken from different places of each fabric, where a specimen is placed on the anvil of a thickness gage and a weighted presser foot lowered gradually taking 5 to 6 seconds to apply full pressure, the displacement between the base and the foot is measured as the thickness of the specimen.

2.6.2. Tearing strength [gm]

Elmendorf Apparatus were used According to the standard D 1424 a samples with area 6.5 cm *9 cm were cute for both sides warp and weft and tested as follows:

Place the long sides of the specimen centrally in the clamps with the bottom edge carefully set against the stops and the upper edge parallel to the top of the clamps. Close the clamps, securing the specimen with approximately the same tension on both clamps. The specimen should lie free with its upper area directed toward the pendulum to ensure a shearing action. Using the built-in knife blade cut a 20 mm [0.787 in.] slit in the specimen extending from the bottom edge and leaving a balance of fabric 43.0 6 0.15 mm [1.69 6 0.005 in.] remaining to be torn.

2.6.3. Air Permeability of textile fabrics [Cm^3/Cm^2/s]

Using Tosyoseliki Air Permeability testing apparatus according to ASTM standard D 737 – 96, three readings were taken from different places of each fabric.

2.6.4. Determination of water permeability [L/m^2. s.]

Using Hydrostatic head tester, model number [FX 3000], according to ISO 12958:1999, a sample was tested from each fabric. The apparatus was assembled with a 20 cm^2 specimen in place where one of its sides is in contact with water and the other side remains exposed to air and it was ensured that all joints were watertight. The water inlet was filled with 10 cm of water. A stopwatch was used to record the time needed by the water to pass through the specimen.

2.6.5. Pilling grade

Standard Test Method ASTM D4970 for Pilling Resistance and Other Related Surface Changes of Textile Fabrics were used by Martindale pilling &abrasion tester apparatus by applying 2000 rubs on the fabric then evaluate its pilling grade using specific light box. Two circle Samples for each fabric were cute with a diameter 15 cm, one for the upper head and the other for the down.

2.6.6. Abrasion [number of rubs when cutting]

The test was carried out using abrading paper [734 silicon carbide P1000] to compare the resistance values between the samples. The endpoint of this test is the thinning of the sample according to EN13770 on the Martindale abrasion machine M235.

2.6.7. Bending length [cm]

Shirley Stiffness Tester were used to determine bending length of the samples according to ASTM – D1388 as follows:

Using the template, cut the specimen to size 6 in. x 1 in. to conduct the test. The fabric underneath the template and specimen is transferred to the platform. Both are now being steadily pushed forward. The fabric strip will begin to droop over the edge of the platform, and the template and fabric will be moved together until the tip of the specimen, as seen in the mirror, cuts both index lines. The bending length can immediately be read off from the scale mark opposite a zero-line engraved on the side of the platform. Each specimen is tested four times, once at each end and once again after the strip has been turned over. Three samples are analysed in this manner. Finally, mean bending length values in the warp and weft directions can be computed.

2.6.8. shrinkage: [%]

Dimensional change of fabrics was determined According to the standard BS 4736[ISO 7771]. As dimensional change equation is

$$\textbf{Dimension change}(\%) = (org.length - length\ after) * \frac{\mathbf{100}}{org}.length$$

3. Results and discussions

3.1. Effect of Chorisia fibers on the properties of the produced weft yarns

3.1.1. Effect of Chorisia fibers on tenacity and elongation% of yarns:

The results in Table 1 indicate that the presence of Chorisia fibers led to a slight rise in the tenacity values of the first blend than that of the second blend. This was unexpected with Chorisia [13]. This may be attributed to three reasons. The first reason was the high content of long fibers in the first blend where the lengths of Chorisia, bamboo, and polyester fibers were 2, 3.8, 3.2 cm, respectively. These long fibers represent 78% of the first blend. The second reason was the low content of the short cotton fibers in the first blend which are 1.3 cm in length while they were high in the second blend where they represent 67% of it. The thinnest count 10/1, gave the most elevated tenacity value due to high twists number that increased by increasing the square root of the yarn count at constant twist factor for all counts in both blends which equals 6.2 according to the relation:

The numbers of twist per inch (T.P.I) = twist factor × √Ne where Ne represents the count in the indirect system. The third reason was that increasing the evenness of the weft yarn and absence of thin places led to high tenacity. The results also showed a slight increase in the elongation of yarns in the first blend. This may be due to the light weight, easy sliding, and extendibility of the Chorisia fibers [13,29].

Table. 1. The effect of Chorisia fiber on the evenness, tenacity and elongation of blended yarns

Blend compositions		Chorisia raw bamboo Polyester waste cotton waste [blend 1]			Bamboo polyester waste cotton waste [blend 2]		
Specimen No		1	2	3	4	5	6
Yarn Ne		10/1	6/1	4/1	10/1	6/1	4/1
Yarn Evenness	U%	7.77	8.69	10.54	9.73	9.24	11.57
	Thick Places	0	24	7	2	0	12
	Thin Places	0	0	0	0	0	0
	Neps	0	0	0	0	0	0
Tenacity [Kgf/den]		3.05	3	1.7	2.72	2.6	1.95
Elongation %		36.93	31.76	28.07	30.64	22.93	19.72

3.1.2. The effect of Chorisia fibers on the evenness and U% of yarn:

The results showed that yarns of both blends were free from thin places and neps, and with a low percent of thick places due to the use of the Open-End spinning in the production of these yarns which increased their evenness where the fibers are subjected to opening and doubling for the entry of rotor [٣0]. The thick places were found due to the unevenness of the fibers along with their longitudinal orientation. U% represents the values of deviation ratio away from evenness. Higher U% values mean less evenness while lower U% values mean more evenness The first blend had lower U% values than the second blend due to the high content of the long fibers including the Chorisia fibers, while the second blend had higher U% values due to the unevenness caused by the high content of the short fibers.[29]

3.2. Radar charts for yarn properties:

The following Radar charts showing yarns properties in presence and absence of Chorisia fibers

3.2.1. Radar chart for first blend [28% Chorisia wastes + 28% Polyester wastes + 22% Cotton + 22% Bamboo fibers] yarns' properties

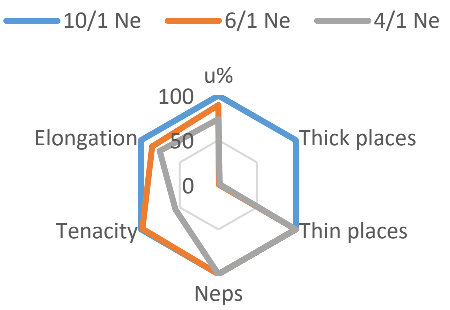

Fig. 4. Radar chart for properties of first blend yarns

3.2.2. Radar chart for second blend [33.33%Polyester wastes +33.33%Cotton wastes +33.33% Bamboo fibers] yarns' properties

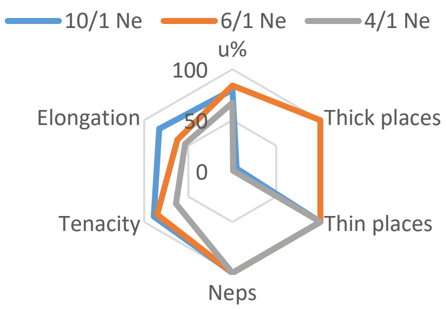

Fig. 5. Radar chart for second blend yarns' properties

3.2.3. Rating the produced yarns by different blends with bamboo and wastes according to Radar chart Area:

Samples were rated descendingly according to the radar chart area of its properties as illustrated in table2.

Table 2. Rating of yarn samples blends of bamboo, cotton wastes and polyester wastes

Rating	Yarn count	Radar chart Area
1	10/1 Ne, with Chorisia	25980
2	6/1 Ne, without Chorisia	20545.18
3	6/1 Ne, with Chorisia	15613.64
4	10/1 Ne, without Chorisia	14651.45
5	4/1 Ne, with Chorisia	11106.86
6	4/1 Ne, without Chorisia	10193.47

Radar charts showed that yarns with count 10/1 Ne with Chorisia gave the most noteworthy properties compared with other yarns by radar chart area [25980], yarns with count 4/1 Ne without Chorisia gave the slightest properties compared with other yarns by radar chart area [10193.47]. It is clearly seen that yarns including Chorisia fibers have a larger radar chart area than yarn samples which are free of Chorisia. Generally, thinner yarn counts showed larger radar chart area than thicker yarn counts .Yarn samples were rated descending by its radar chart area in table 2 , as it is well known that higher radar chart area mean better properties.

3.3. Effect of Chorisia fibers on the properties of the produced woven fabrics

The fabric test results are shown in Table 3

Table 3. The properties of woven fabrics in presence and absence of Chorisia fibers

Blend No.		First			Second		
Specimen No		1	2	3	4	5	6
Yarn count [Ne]		10/1	6/1	4/1	10/1	6/1	4/1
Pick/cm		18	12	10	18	12	10
Thickness [mm]		0.57	0.71	0.82	0.52	0.59	0.78
Tear strength [gm]	Warp	10300	9900	9400	10550	12100	9800
	Weft	12800	11550	10100	12700	10700	9450
Air permeability [$Cm^3/Cm^2/S$]		163.8	144	121.7	174.5	298.2	200.6
water permeability [$l/m^2/S$]		0.93	1.2	1.24	1.32	1.38	1.44
Pilling grade after 2000 cycle		3	2-3	3	1	1-2	2
Abrasion [Number of rubbings]		160	99	70	43	43	93
Bending length [cm]	Warp	4.7	3.7	3.3	3.9	3.7	3.05
	Weft	5.5	4.1	3.7	4.1	3.	3.5
shrinkage [%]	Warp	9.5	13	14	10	13	14.5
	Weft	3.5	5	6	3	4.5	5

3.3.1. The effect of Chorisia on the fabrics' thickness:

The presence of Chorisia in the first blend caused a slight rise in the fabrics' thickness as Chorisia fibers have thin wall and wide lumen which gave the fibers their bulky appearance and therefore their high thickness [4,13]. At the count 4/1, the fabrics had the most increased thickness compared to that of the same count in second blend because of the large number of fibers in the cross section of the yarns and high picks regarding its thick count and higher Chorisia percentage [12].

3.3.2. Effect of Chorisia on the fabrics tear strength:

The increase of the fabrics' tear strength in the weft direction in the first blend was slightly more than that of the second blend because the weft of the first blend had higher tear strength. The tear strength of the wefts at count 10/1 was the highest compared to 4/1 of the same blend because of the great number of picks which equals 18 and TPI [12]. Likewise, the yarns' movement was free in the satin woven structure with few interlacing per cm² which increased the tear resistance of the fabrics. It was observed that the tear strength of the warp direction was decreased compared to the wefts in the first blend due to the bulking of the wefts that contained Chorisia, which led to an increase in the tensile ratio of the warps when passing the picks through the shed. Therefore, the warp tear strength decreased, which means less tearing resistance, and this appears clearly in the higher values of the tear strength of the warps yarns in the first blend compared to warps in the second blend due to the absence of Chorisia.

3.3.3. Effect of Chorisia on air and water permeability

The results showed low values of air permeability in the first blend which contains Chorisia fibers that have wide lumen and thin wall acting as air insulator. The most noteworthy air permeability values were these of the specimens 2 and 3 that had high fabrics' thickness, whereby increasing the thickness, the air permeability decreased, and vice versa [24]. Additionally, the weaving construction of satin 4 had few numbers of interlacing between warps and wefts, in cm², and therefore had little pores, which decreased the air permeability. The second blend at 6/1, had higher values of air permeability despite the high fabric thickness compared to that of 10/1 of the same blend due to the air passage through either one of two ways, the fabrics' pores or the yarns' core and because 6/1 had lower TPI than 10/1, therefore, higher pores which led to higher values of air permeability [30]. In the first blend, it was found that the TPI is not the main factor affecting the air permeability, but it was the Chorisia fibers percentage. When comparing the air permeability values of the counts of the first blend, it was found that 4/1 had both low TPI and air permeability due to the presence of high content of the Chorisia fibers and vice versa at 10/1. The water permeability had low values in the first blend which contains the raw Chorisia fibers due to the presence of non-cellulosic materials as ash, lignin, wax and high contact angle on water which caused the low permeability of water [31]. From the results, the second blend had more comfort than the first blend due to the high content of bamboo fibers which had comfort properties leading to high values of both air and water permeability.

3.3.4. Effect of Chorisia on pilling of fabrics:

The pilling values assessment of the first blend was higher than that of the second blend, where it was close to 5 which showed less pilling, and this was due to the presence of the Chorisia fibers with their smooth and silky surface which declined the presence of pilling. The evaluation of the second blend was close to 1 which implied higher pilling as a result of the presence of high content of polyester and cotton wastes that caused the increment of hairiness and thus pilling of the fabrics surfaces [30,12]. The Open-end spinning technique that was used to produce the yarns was the reason of their decreased hairiness thus the decreased fabrics' hairiness.

3.3.5. Effect of Chorisia on the fabric's abrasion:

In order to cause fabrics' abrasion in the first blend, high number of rubbings were required, and this was because of the high reinforcement of the wefts and the Chorisia fibers which had smooth and silky surface that provide the yarns and the fabrics' surface with some kind of smoothness, which decreased the friction [12] between the fabrics and the abrading paper during doing the test. Likewise, the non-cellulosic materials as lignin and wax act as high shield that may help the resistance of the fabrics to abrasion. In the first blend, 10/1 had the highest abrasion compared to 6/1 due to the high TPI that gave reinforcement to fabrics' resistance to abrasion, along with the decrease in the thickness of the fabrics, which reduced their hardness. This hardness led to abrasion resistance.

3.3.6. Effect of Chorisia on the bending length:

There was an increase in the bending length which indicates the disability of the fabrics bending in the direction of wefts. It demonstrated the high stiffness of the fabrics in the first blend, and this was due to the high content of the non-cellulosic materials as lignin and wax, the wide hollow lumen of the Chorisia fibers and increasing the TPI of wefts. All these factors increased the fabrics' stiffness and when it increased, the bending length increased [32], as shown in specimens 1, 2, and 3. Also, in the first blend, TPI of wefts had an important role. When they increased, the bending length increased. This was clear in the values of the bending length at the 10/1 compared to ٦/1 and 4/1. Regarding the higher values of the bending length in the direction of the warp, this was due to the sizing process, which strengthened the yarns and made them more rigid and stiff to resist stress during the fabrics' production. The difference in the values of the bending length in the warp yarns may be due to the inefficiency of the sizing process.

3.3.7. Effect of Chorisia on the shrinkage%:

The shrinkage % values of the specimens of both blends were due to the incorporation of the wefts and warps on washing the specimens. This incorporation caused the length decline in the direction of both the wefts and warps. Additionally, the involved woven structure in the specimens made the wefts and warps in a free movement which facilitated the incorporation. The shrinkage% in the weft direction was higher in the first blend as it contained the Chorisia fibers which facilitated the incorporation because of their smoothness, lightness and the high elongation of weft yarns which their recovery led to high picks per cm and increased shrinkage. The shrinkage% of the two blends in the warp direction was higher than that of the weft direction due to the tension applied on the warps yarns during the manufacturing process.

3.4. Radar charts for woven fabrics properties

3.4.1. Rating the woven fabrics by Radar chart Area:

Radar chart area for each sample was calculated and rated as in table 4

Table 4. Rating of fabric samples blends of bamboo , cotton wastes and polyester wastes

Rating	Sample	Radar chart Area
1	10/1 Ne, with Chorisia	23184.53
2	6/1 Ne, with Chorisia	20861.69
3	4/1 Ne, without Chorisia	20851.27
4	10/1 Ne, without Chorisia	20776.34
5	4/1 Ne, with Chorisia	18501.81
6	6/1 Ne, without Chorisia	17810.82

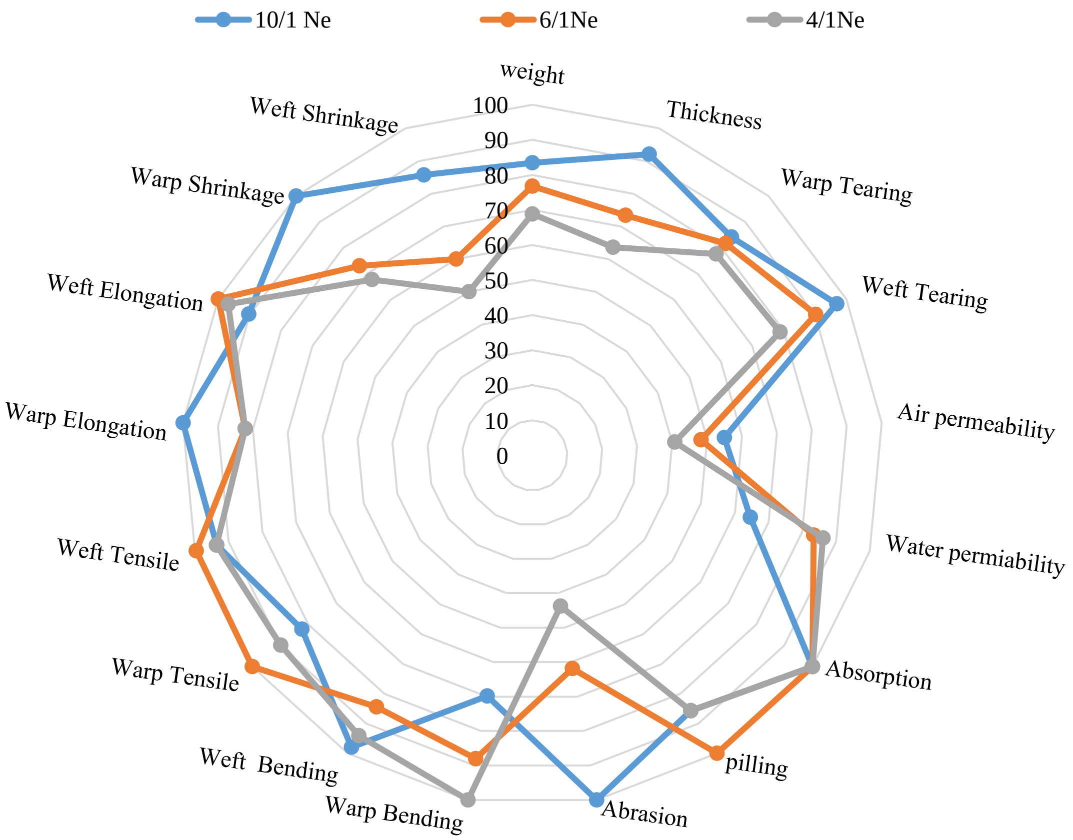

Fig. 6. Radar chart for first blend fabric' properties in presence of Chorisia fibers

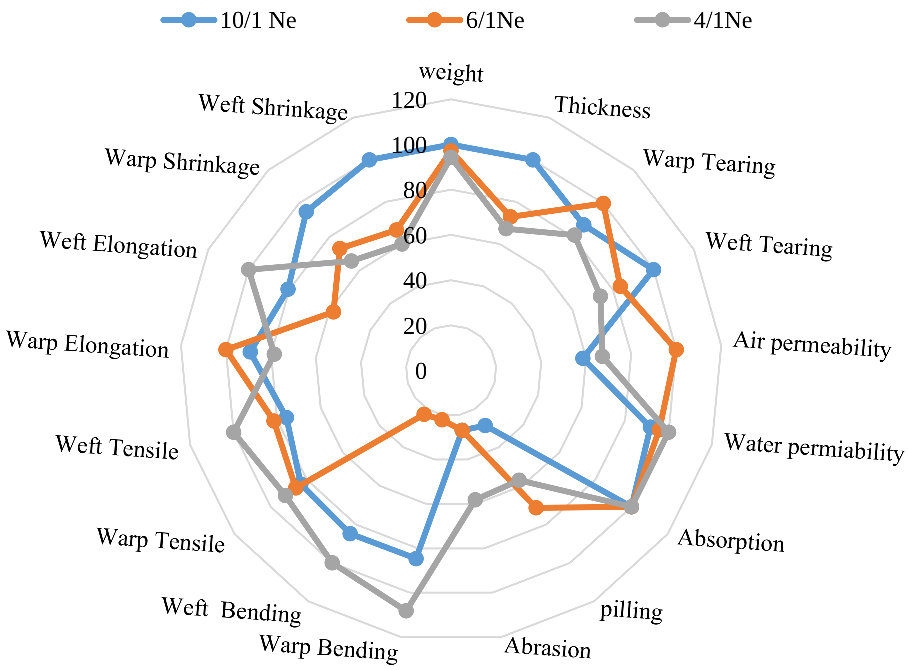

Fig. 7. Radar chart for second blend fabric' properties in absence of Chorisia fibers

Radar charts (figure 6&7) showed that yarns with count 10/1 Ne with Chorisia gave the highest fabric' properties comparing with other yarns by radar chart area [23184.53], yarns with count 6/1 Ne without Chorisia gave the least properties comparing with other yarns by radar chart area [17810.82].

It is also clear that woven fabrics from yarn count 10/1 Ne, 18 picks per cm , by blend 1 with Chorisia has the highest performance in comfort and mechanical properties by the largest radar chart area [23184.53], followed by sample from yarn count 6/1 Ne , 12 pick per cm , by blend 1with Chorisia by radar chart area [20861.69]. Followed by other samples as shown in the table 4.

4. Conclusion

This work has succeeded in disposing all the downsides concerning blended fabrics' mechanical and comfort properties in our past examination. The presence of Chorisia positively affected the blend of cotton and polyester wastes and pure bamboo. It improved the tenacity, the yarn's quality, and the regularity, as well as lessening the U%. On the other hand, the woven fabrics gained higher tearing strength and thickness in the presence of Chorisia, which acted additionally as an insulator against air and water, owing to the large lumen and wax of Chorisia fiber, and reduced the pilling of the woven fabrics and their comfort. Likewise, adding Chorisia into blended fabrics improved the fabrics' resistance to abrasion, but it negatively affected the bending length, which caused increasing in the bending length, stiffness, and the shrinkage % of fabrics in the weft's direction. This study considers the use of cotton and polyester wastes and the major difficulty in recycling textile wastes which limits the regenerated products for low value applications, such as second hand clothing and basic fiber content. This work could provide alternative solutions for the recycling of fibrous wastes generated from post-industrial wastes using reasonable and economical operations through the blending with the Chorisia fibers to produce a variety of marketable and high-value products. Also, it could be used in the production of winter clothes.

5. Acknowledgement

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