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Ecofriendly product development from Roselle and ramie blended fabric

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Abstract
In India, Assam state is endowed with plenty of natural plant resources. Among all, many of them are fibre yielding plant varieties such as agave, nettle, cannabis, hibiscus etc. One of the most noticeable bast fibre crops is roselle (*Hibiscus sabdiriffa*) which is widely grown in Assam but yet not gained any commercial importance. Roselle fibre is used mainly by local people in the state for cordage, ropes, canvas fabric, household utility items etc. An attempt had been made to utilize the stem part by blending it with ramie, another natural fiber. Blending is done at fiber stage in jute spinning machine. Different physical test of fabric was conducted to study the efficiency of the blended product. The present study is an approach towards value addition of roselle fiber to contribute in textile market through product diversification. Proper utilization of roselle fibres in the form of attractive handloom products will add to its commercial value. This study will open new ways for the creation of diversified hand spun and hand woven products of roselle and will inspire textile designers for the development of unique eco-friendly range of products.

Keywords: ecofriendly, ramie blended fabric, natural plant resources

Introduction
Today's world is conscious about environment and natural clothing lifestyles are more prevailing. The attraction towards eco-friendly textiles alternatives and the emergence of innovative fabrics is increasing. The growing concerns about health, sustainability of waste management and environmental awareness which is reflecting on renewed interest in plant fibers. Recent growing concerns are health, sustainability of waste management and environmental awareness which is reflecting on renewed interest in plant fibers (Gokhale and Katli, 1995) [5]. Natural fibre is a type of renewable sources and well known for their bio degradability, non-carcinogenic and eco/health-friendly nature. Natural fibres are one such emerging material which replaces the synthetic materials and its related products for the environmental conservation applications. (Joshi *et al.,* 2004, Vastrad *et al*., 2012) [7, 11].
In the field of Textiles the present time can be truly called as the period of blending. Blending different types of fibers is a widely practiced means of enhancing the performance and the esthetic qualities of a fabric. Fiber blending can achieve quality products that cannot be fulfilled by only one single yarn properties and it can also cut down the price of more expensive yarns with low expensive one and also synthetic fiber with natural one. Recently, due to improvement of the peoples living standard and need for environment protection, the demand of natural biodegradable and ecofriendly products is rising worldwide day by day (Ghosh P, 2004, Gordon, C.J. 2005) [4, 6]. The increased demand in the natural product due to their low cost, low density, biodegradability, renewable and abundance. Considering the exclusive properties of ramie and roselle fiber, the researcher had aimed to blend the yarns to form value added products.

Methodology
Selection of plant
The Roselle plant utilized for the present study was AS73, CP 560 variety, collected from the farmer's field of Potya gaon, Jorhat, Assam. It is an annual or perennial herb or woody base sub-shrub, growing to 2-2.5m (7-8ft) tall. The leaves are deeply three to five lobed, 8-15cm (3-6inch) long, arranged alternatively on the stems.

The ramie fiber variety R1412 were selected for the study and collected from Ramie Research Station, Shorbhog, Assam. Ramie is a flowering plant in the nettle family Urticaceae, native to eastern Asia. It is herbaceous perennial growing to 1-2.5m tall.

Extraction of Fiber

The fibers were extracted by using water retting.. Retting was carried out in retting tank with a constant material to liquor ratio of 1:10 at room temperature and kept for five different duration of days interval *viz.,* 20, 23, 26 and 29 days, after definite time interval of retting.

Degumming and bleaching process

In degumming process, 1:10 bath ratio was maintained. Extracted fibre treated with 3% solution of Na_2CO_3 at 95°C for 2 hours. The degummed fibres were rinsed with cold water, neutralized with 2% acetic acid, rinse again until neutral pH and dried at 50°C in a vacuum oven. During degumming, certain amount of lignin, wax and oils, which covering the external surface could also be removed. However, this degumming can increase the tensile modulus and strength of the roselle fibre over those of untreated fibres. (Kalita 2005) [8].

Bleaching is done by using alkaline hydrogen peroxide with material to liquor ratio 1:10 at 90°C, pH 10-11 for 60 minutes in a close vessels. After bleaching, fibre washed properly and air dried. Natural colour removed from the fibre during bleaching and fibres attend good whiteness. (Kalita 2005) [8]

Blending process

For this study the blending of roselle fibre and ramie fibre were done at carding stage at the ratio of 25:75 (roselle and ramie), 50:50 (roselle and ramie) and 75:25 (roselle and ramie). Researches in the world, are trying to blend roselle fibre with other fibre at different blend properties to get suitable yarn. The present investigation also tried to blend roselle fibre with ramie at ratio of 60:40, 50:50and 40:60. The blending process, were not found suitable to get the proper yarn due to the breaking of sliver. On the other hand, blending proportion of 50:50 showed better quality yarn thereby selected for further study. Along with the blending proportion 100% roselle and 100% ramie fibre were also used to prepare the yarn for comparing with the blending yarn.

Construction details of woven fabric

The developed fabrics were woven in a fly shuttle loom by using blended yarns in the Moromi Handloom, Lichubari, Jorhat, Assam. Both controlled and blended fabrics were woven in plain weave construction.

Evaluation of physical properties of blended fabrics

Prior to testing, all the samples were conditioned to attain moisture equilibrium and tested in standard atmospheric condition of 65±2% relative humidityand temperature 27±2ºC as per IS Standard Method IS- 6359-1971, (ISI Handbook of Textile, 1982).

Fabric count in woven textile material is the number of ends and picks per unit area, while the fabric is free from wrinkle. Count of the specimen/sample were determined with the help of picks glass by BS Method 2862:1957 (Booth, 1968).To count numbers of warp and weft yarns in one square inch of the fabric was counted randomly at selected places across the width and along the length of the test specimen by using magnifying counting device. Further, mean value of end and picks per inch are calculated.

In fabric technology, the openness or the closeness of a fabric is expressed by cover factor. The formula for calculating cover factor was

$$K = n/N$$

Where, K= cover factor

n = Thread per inch

N = Count of yarn

Cover factor are calculated separately for warp and weft.

Further, from each pair of cover factors, the cloth cover factor was calculated by using the following formula.

$$Kc = (K1+K2)+K1K2/28$$

Where, Kc = Cloth factor

K1 = Warp cover factor

K2 = Weft cover factor

Fabric Thickness was measured by using fabric thickness tester as per BST test method 2544:1954 (Booth, 1968).Fabric stiffness is the resistance of fabric to bending. Bending length is the length of the fabric that bends under its own weight to a definite extend. It equals half the length of rectangular stripe of fabric that bends under its own weight to an angle of 41.5ºC. The test samples were tested as directed in BS test method: 3356-1961.

Crease recovery is nothing but allowed the fabric to recover from the crease. The test sample tested as directed in I.S method: 4681-1968 by using the Shirley's crease tester. The weight of the fabric is described as weight per unit area in terms of grams per square metre. The fabric samples were cut with the help of GSM cutter and were weighed on digital balance. Five readings were taken for each sample. The GSM (Gram per square meter) was calculated.

Assessment of functional properties of fabrics

Tensile strength was tested as directed in ASTM test method: 12676-1989. The method employed to determine the breaking load and elongation of the material by using the 'strip test' in Instron tensile tester.

Fabric drape may be explained as the extent to which a fabric deforms when it is allowed to hang under its own weight.. Thus drape co-efficient was calculated by using following formula:

$$F = As-Ad/(AD-Ad) \times 100$$

Where, AD = the area of specimen

Ad = the area of supporting disk

As = the actual projected area of the specimen

Drape co-efficient F, was the ratio of the projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk

Miller Tyomkin (1984) [9] pointed out that spontaneous uptake of liquid in fabric has always been called wicking, also stated that when a porous material such as fabric is placed in contact with liquid, spontaneous uptake of liquid may occur.

The fabric were also tested for Air permeability directed by IS test method 11056: 1984.,Cloth tearing strength is determined as per IS test method: 6489-1971.

Tear strength (g) is calculated using formula

Mean tearing strength (g) = K X mean value of scale reading

Where the value of K is

16= without any augmenting weight
32= with augmenting weight of 3200g
64= with both augmenting weights

Preparation of value added and diversified products
The controlled and blended fabrics were utilized for preparation of different products. Sewing were used to prepare products from the fabrics. Different drafting methods were followed to design and construct value added and diversified products.

Subjective evaluation of woven fabrics and diversified products
Assessment of visual properties of the controlled and blended fabrics and end products were assessed by taking 100 respondent comparing PG students and faculty members of College of Home Science and College of Agriculture, Jorhat, Assam.
Some important properties such as appearance (Rating scale:- 3-Good, 2-Fair and 1-Poor), texture (Rating scale:- 3- Fine, Medium and 1-Rough), luster (Rating scale :- 3- High, 2- Moderate and 1- Low), Handle (Rating scale :-3- Soft, 2- Crisp and 1- Stiffs) and suitability (Yes and No) of products were assessed by the respondents with the help of Performa. Later, the results were expressed in terms of percentages (Appendix I).

Statistical analysis
The data obtained from laboratory determinations were analysis through Completely Randomized Design and subjected to analysis of variance by ‘F’ test. This significance of variance due to treatment was determined by calculating the respective F value (Panse and Sukhatme, 1978).

Result and Discussion
Fabric count in woven textile material is the number of warp yarns (ends) and weft yarns (picks) per inch of a fabric. The controlled and blended fabric has shown different fabric counts. Controlled ramie fabric showed highest count in weft way (27) and in warp (25) direction and least was found in roselle fabric in weft way (24) and in warp it is (26). The highest twist of ramie in weft direction might be responsible for highest count in the ramie controlled fabric sample as the twist of yarns affect the twist of yarn compactness.
The table also depicted that in blended fabrics, maximum count both in warp (27) and weft (30) direction was recorded in 50:50 blend ratio of roselle and ramie followed by roselle/ramie (25:75) and roselle/ramie (75:25) (warp 26, weft 26 and warp 25, weft-24), respectively. The difference of count existed among the fabrics might be due to the beating process involved in weaving stage and also the amount of the twist presented in the yarn.
In case of total cloth cover table 3 showed that the controlled fabrics, the highest cloth cover was found in roselle (0.091) fabric and then ramie controlled fabric (0.085). Whereas in case of blended fabrics, roselle and ramie blended at 50:50 showed (0.086) more cloth cover then roselle and ramie blended at 25:75 and 75:25 (0,073, 0.064) respectively. The statistical result showed highest cover factor and cloth factor in roselle fabric might be due to its highest twist which may affect the count of the yarns and in turns affect the cover factor.
An increasing trend in case of weight and thickness of the controlled roselle fabric shown in table 4 Among the controlled fabric highest thickness (0.72mm) and weight ($250g/m^2$) was observed in roselle fabric while, ramie fabric showed least thickness (0.67mm) and weight ($240g/m^2$). Angappan and Gopalkrishnan (2002) [1] also quoted that thickness of woven fabric samples depends upon coarseness of yarn, as higher the yarn diameter, thicker the fabric. In case of blended fabric observation was made that, there was a decreasing trend in weight and thickness of the fabric. In comparison between the blended fabrics it was observed that thickness of roselle and ramie blended fabric 25:75 showed highest thickness (0.76mm) and weight ($250g/m^2$), while roselle/ramie 50:50 showed minimum thickness (0.66mm) and weight ($240g/m^2$). The variation of thickness and weight among the fabric might be due to the fabric types as well as amount of twist present in the yarn. The roselle/ramie blended fabric 25:75 had more weight as compared to other samples because it was woven densely with two sets of yarns hence weight was increased with more number of threads per unit area.
The table 5 revealed that among the controlled fabrics, roselle fabric has the highest crease recovery angle both in warp (140) and weft (130) direction. Subsequently, the same fabric posed minimum stiffness of 4.4cm and 4.7cm in warp and weft direction respectively. Relating to ramie fabric, it has minimum crease recovery of 130 and 120 degree in warp and weft direction where the minimum stiffness (warp-4.3cm, weft- 4.5cm) of the fabric was encountered. It was found from the present investigation that among the blended fabrics roselle and ramie blended at 50:50 showed maximum crease recovery angle of 140 and 130 degree in warp and weft direction respectively. On the other hand stiffness was exhibited by the same fabric in both the direction (warp 4.2, weft- 4.5). The roselle and ramie blended at 25:75 showed minimum crease recovery angle of 120 and 110 degree in warp and weft direction respectively and stiffness in this ratio (warp- 4.5, weft- 4.7).From the above findings, it was interesting to note that crease recovery and stiffness of fabrics has an indirect relationship. The fibre types, thickness and weight of the fabrics might be responsible for variation of crease recovery and stiffness of controlled and blended fabrics.

Functional properties of controlled and blended fabrics
The tensile strength and elongation of controlled and blended fabrics were assessed and data were systematically presented in Table 6. Among the controlled fabrics highest tensile strength was showed by roselle 100% in the warp (86.50kgf) and weft (75.44kgf) direction while minimum tensile strength of 79.55 and 70.54kgf were registered in ramie 100% fabric both in warp and weft direction respectively. In blended fabrics, it was seen that fabric roselle-ramie 50:50 recorded the maximum tensile strength (warp-78.45kgf, weft-68.45kgf) as compare to fabric the roselle-raime 25:75 and roselle-raime 75:25 (warp-74.56kgf, weft-67.54kgf and warp- 71.87kgf, weft-65.35kgf). The maximum elongation was noticed in raime100% fabric (warp-17.23%, weft-16.25%) whereas. The least elongation was observed in roselle100% fabric both in warp (15.45%) and weft (16.40%) direction. In terms of blended fabrics, roselle-raime 50:50 (warp-18.45%, weft-19.40%) and roselle-raime 25:75 (warp-18.35% and weft-19.45%) the least elongation shown in roselle-raime 75:25 (warp-17.50% and weft-18.56%).
The drape co-efficient of plain weave blended fabrics were systematically analysed and the data were recorded in Table 7. Drape is the ability of the fabric hang in graceful fold. Fabric drape is the extent to which a fabric will deform, when

it is allowed to hand under its own weight. It is largely affected by the yarn twist.. It depicted that among the controlled fabrics, highest drape co-efficient (60.5%) was recorded in ramie fabric and least was observed in roselle fabric (60%). In case of blended fabric highest drape coefficient was found in roselle. The air permeability of controlled and blended fabrics were systematically analyzed and the data recorded in Table 7. It is observed that highest air permeability was found in controlled ramie fabric (2360 s) and least was observed in roselle fabric (2320s). In case of blended fabrics maximum air permeability were found in both the roselle-ramie 50:50 and roselle-ramie 75:25 fabrics (2340s), whereas minimum air permeability were recorded in roselle-ramie 25:75 fabric (2300s).

In comparison between the controlled and blended fabrics, highest tearing strength was found in ramie 100% fabric (warp-30g/m², weft-35g/m²) and least was observed in roselle 100% fabric (warp-25g/m², weft-30g/m²). In case of blended fabrics roselle-ramie 75:25 have highest tearing strength (warp-30g/m², weft-35g/m²), whereas minimum tearing strength recorded in roselle-ramie 50:50 (warp-26g/m²,weft-35g/m²).

The thermal insulation of controlled and blended fabrics were analysed and data were recorded in the Table 8.In case of controlled fabrics the maximum thermal insulation were recorded in ramie fabric (0.196tog) and minimum were found in roselle fabric (0.168).The blended fabrics showed increasing trends of thermal insulation. The maximum thermal insulation were recorded in roselle/raime 75:25 (0.17tog) followed by roselle/ramie 25:75 (0.134tog), whereas, minimum thermal insulation found in roselle/ramie 50:50 (0.103tog). Among controlled fabrics, the highest thermal conductivity was found in ramie fabric (0.214 CLO) and minimum were recorded in roselle fabric (0.114CLO). The highest value of thermal conductivity for controlled fabric was responsible for its better heat transfer. In case of blended fabric the maximum value of thermal conductivity were noticed in roselle/ramie 75:25 (0.157CLO) followed by the roselle/ramie 50:50 (0.126CLO) whereas, minimum thermal conductivity recorded in roselle/ramie 25:75 (0.062 CLO).

Response of Respondent

The controlled and blended fabrics were evaluated and assessed through visual inspection for fabric appearance, luster, texture, handle and suitability of the product prepared from the fabrics. It was found that the majority of respondent were belongs to the age group of 22-27 years (90%) followed by 27-32 year (60%) and 32-37 above (50%). It was also observed that 90% respondent were post-graduates holders followed by undergraduate (90%) and doctorates (20%). 180% of the respondents were students followed by 20% were employed. It was observed that the general appearance was categories as good, fair and poor. Respondent opined that all woven samples have good, fair and poor. Respondents opined that all the woven samples have good appearance where 100 percent respondent stated roselle-ramie (50:50) and roselle-raime (75:25) having good appearance. On the other hand, 15 percent respondent gave their opinion as fair in case of roselle controlled fabric. It was observed that majority of the respondent viewed all the fabrics as moderate in texture, Whereas in roselle-ramie (50:50) fabric, a few respondents stated the fabric as fine. A few number of respondents rated the roselle100%, ramie100%, roselle-raime 25:75 and roselle-ramie 75:25 as rough in texture. Majority of respondents opined all the controlled and blended fabrics were moderate in luster where cent percent respondent were rated roselle-ramie 75:25 as moderate. It was interesting to observe that cent percent respondents stated the fabric roselle 100% were found crisp in hand while sample roselle100%, roselle-ramie 25:75, roselle-ramie 50:50 and roselle-ramie 75:25 were rated as crisp and slightly soft. 100 per cent respondents opined that the girls jacket, shopping bag, clutch bag, laptop bag, girls dress, cushion cover and waist coat were suitable

Table 1: Construction details of woven fabric

SI. No.	Sample	Weave	Type of loom	Yarn count	Reed count	Loom pick	Cloth width
1.	Roselle 100%	Plain	(Hand loom fly shuttle)	40s	52	46	40
2.	Ramie 100%	Plain		40s	52	46	40
3.	Blended RF-ramie fibre 25:75	Plain		40s	52	46	40
4	Blended RF-ramie fibre 50:50	Plain		40s	52	46	40
5.	Blended RF-ramie fibre 75:25	Plain		40s	52	46	40

Table 2: Nomenclature of the samples

S.No	Sample code	Yarn content
1.	RF	Roselle fibre
2.	RaF	Ramie fibre
3.	RRaF	Roselle fibre 25 × ramie fibre 75
4.	RRaF	Roselle fibre 50 × ramie fibre 50
5.	RRaF	Roselle fibre 75 × ramie fibre 25

Table 3: Cover factor and cloth cover of controlled and blended fabrics (Numerical Expression)

Fabric	Cover factor		Cloth cover
	Warp way	Weft way	
Controlled fabrics			
Roselle fabric	0.37	1.60	0.091
Ramie fabric	0.34	1.54	0.085
Blended fabrics			
Roselle-Ramie 25:75	0.26	1.44	0.073
Roselle-Ramie 50:50	0.28	1.67	0.086
Roselle-Ramie 75:25	0.28	1.20	0.64
SEd(±)	0.11	0.29	0.005
CD(0.05)	0.23	0.61	0.012

Table 4: Thickness and weight of controlled and blended fabrics

Fabric	Thickness (mm)	Weight (g/m²)
Controlled fabrics		
Roselle fabric	0.72	250
Ramie fabric	0.67	240
Blended fabrics		
Roselle-Ramie 25:75	0.76	250
Roselle-Ramie 50:50	0.66	240
Roselle-Ramie 75:25	0.68	250
SEd(±)	0.04	3.74
CD(0.05)	0.08	7.80

Table 5: Crease recovery and stiffness of controlled and blended fabrics

Fabric	Recovery (Degree)		Stiffness (cm)	
	Warp way	Weft way	Warp way	Weft way
Controlled fabrics				
Roselle fabric	140	130	4.40	4.70
Ramie fabric	130	120	4.30	4.50
Blended fabrics				
Roselle-Ramie 25:75	120	110	4.50	4.70
Roselle-Ramie 50:50	140	130	4.20	4.50
Roselle-Ramie 75:25	130	120	4..30	4.80
SEd(±)	2.64	2.64	0.30	0.24
CD(0.05)	5.51	5.51	0.63	0.50

Table 6: Tensile strength (kg f) and elongation (%) of controlled and blended fabrics

Fabric	Tensile strength (kgf)		Elongation (%)	
	Warp way	Weft way	Warp way	Weft way
Controlled fabrics				
Roselle fabric	86.50	75.44	15.45	16.40
Ramie fabric	79.55	70.54	17.23	16.25
Blended fabrics				
Roselle-Ramie 25:75	74.56	67.54	18.35	19.45
Roselle-Ramie 50:50	78.45	68.45	18.45	19.40
Roselle-Ramie 75:25	71.87	65.35	17.50	18.56
SEd(±)	2.88	3.92	0.45	0.54
CD(0.05)	6.01	6.01	0.95	1.13

Table 7: Air permeability, Drape coefficient and tearing strength of controlled and blended fabric

Fabric	Air permeability (s)	Drape co-efficient (%)	Tearing strength(g/m²)	
			Warp way	Weft way
Roselle fabric	50	60	25	30
Ramie fabric	2360	56	30	35
	Blended fabrics			
Roselle-Ramie 25:75	2300	56	30	25
Roselle-Ramie 50:50	2340	60	26	35
Roselle-Ramie 75:25	2340	80	30	35
SEd(±)	80.49	4.73	3.72	3.07
CD(0.05)	167.91	9.87	7.76	6.40

Table 8: Thermal insulation and thermal conductivity of the controlled and blended fabrics

Fabric	Thermal conductivity(CLO)	Thermal insulation (tog)
Controlled fabric		
Roselle fabric	0.114	0.168
Ramie fabric	0.214	0.196
Blended fabric		
Roselle-ramie 25:75	0.062	0.134
Roselle-ramie 50:50	0.126	0.103
Roselle- ramie 75:25	0.157	0.170
S.Ed	0.132	0.142
CD	0.23	0.25

Table 9: Production cost of different items

Different products	Requirements of fabric (cm/m)	Rate of fabric/meter (Rs)	Amount (Rs)	Labour cost (Rs)	Total (Rs)
Girls dress	2m	360	720	500	1220/-
Waist coat	1m	360	360	500	860/-
Girls jacket	1.5m	360	540	800	1340/-
Laptop bag	30cm	360	108	500	608/-
Shopping bag	20cm	360	72	200	272/-
Table mat	1m	360	360	200	560/-
Cushion	20cm	360	72	50	122/-
Clutch bag	15cm	360	54	150	204/-
Slipper	10cm	360	36	100	136/-
Mobile cover	10cm	360	36	30	66/-

Table 10: Respondent opinion for suitability of the fabric for the prepared diversified products

Fabric	Products	Suitability (%) Yes	No	Approx. Cost (Rs.)
Roselle 100%	Table mat Girls jacket	98 100	2 --	560/- 1340/-
Ramie 100%	Shopping bag Slippers	100 95	-- 5	272/- 136/-
Roselle- ramie 25:75%	Clutch bag Laptop bag	100 100	-- -	204/- 608/-
Roselle- ramie 50:50%	Girls dress Cushion cover	100 100	-- --	1220/- 122/-
Roselle-ramie 75:25	Waist coat Mobile cover	100 95	-- 5	860/- 66/-

Conclusion

Blending of roselle and raime fibre was an attempt to compensate the properties of each fibre as well as the reduction of cost. Besides this blending also opens up ways for range of diversified products by offering some new and unique products to the market. From the present investigation it may be concluded that roselle and ramie blended fabrics have good potential for exports owing to their economics, aesthetic appeal and improved functional properties. Quality characteristics of fabrics produced from blending of roselle and ramie can be utilized for the manufacture of dress materials and different value added product with distinct characteristics. It also opens wide scope of diversifications into the manufacture of home textiles like interior fabrics and furnishings

References

1. Angappan P, Gopalakrishnan R. Textile testing. Komarapalayam, S.S.M. Institute of Textile Technology, 2002, 480.
2. ASTM Test Method (D). Breaking load and elongation of textile fibre, 1962-1964.
3. Booth JE. Principle of Textile Testing. Third Edn., Newnes Butter word, London, 1968, 353-354.

4. Ghosh P. Effect of Selective Chemical Treatmentof Jute Fibre on Textile Related Propertie sand Processible Indian Journal of Fibre and Textile Research. 2004; 29:85-89
5. Gokhale C, Katli V. Golbalizing Indian Textiles: Threats and Opportunities, First Edn. Tecoya Publ. Co., Mumbai, 1995, 59.
6. Gordon P. Handbook of Textile Fibre 5th Edition, Abington Hall, Abington, Cambridge. 2005, 13-16, 64-70.
7. Joshi S, Drzal L, Mohanty A, Arora S. Are natural fiber composites environmentally superior to glass fiber reinforced composites Composites Part A: Applied Science and Manufacturing. 2004; 35(3):371-376
8. Kalita BB, Saikia SR, Kaur S. Influence of blend ratio in the properties of bamboo and silk woven fabrics". International Journal of Scientific and Research Publications. 2015; 5(6):2250-3153.
9. Miller, Tyomkin, I. Spontaneous transplanar uptake of liquid by fabrics. Textile Res. J. 1984; 56(10): 706-712.
10. Panes VG, Sukhatme PV. Stastical method for agricultural workers, ICAR Delhi, 1978, 48-123.
11. Vastrad JV. Utilization of mesta fibres for textile application. International symposium on Agriculture and environment publ., university of ruhuna Sri Lanka, 2012, 76.