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Research Paper

Designing eco-friendly fabrics from naturally colour linted cotton

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ABSTRACT : Two genotypes of naturally brown coloured cotton yarns *viz.*, Dharwad desi colour cotton – 1 (DDCC-1) and Dharwad brown hirsutum – 250 (DBH-250) were woven on handloom with white cotton and filature silks (Muga and Tasar) to produce user and ecological friendly fabrics. Japanese kawabata evaluation aystem assessed these union fabrics for their performance. The results revealed that union fabrics showed higher tensile, bending, shear, compressional and surface property values indicating the fabrics having low bending rigidity and fabric density, greater flexural rigidity, coarse and rough to handle than their corresponding control samples. Koshi (stiffness), numeri (smoothness), fukurami (fullness and softness) and sofutosa (softness) were the primary hand values of KES (FB) in turn assisted to rate the total hand value. The total hand value expressed that these union fabrics are most suitable (good to excellent) for women's winter thin dress and fairly suitable (fair to good) for women's winter suits. Thus, newly woven union fabrics being new and unique of its kind are not only suitable for dress material but also as furnishings. All along its length, the handspun DDCC-1 yarn showed unequal distribution of slubs and snarls which is an added advantage of fancy appearance and texture of handloom fabric. Therefore, it is a boon for cotton cultivators to grow colour cotton on commercial scale to sustain in both domestic and international market as well as support the handloom sector.

KEY WORDS: Colour cotton, KES (FB), Surface properties, Tensile properties, Union fabrics

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Cotton, the king of textile fibre is one of the world's most socially vital and economically important agricultural cash crops. It has always played a very important role in the lives of Indians and thus called as the "fabric of India". India holds the largest area under cotton cultivation and ranked third in world's cotton production, next to China and USA and second largest consumers of cotton.

Majority of cotton grown commercially in the world is white lint but in recent years the colour linted cotton has gained popularity. Compared to white cotton, naturally colour linted cotton is short, coarse and weak, thus, submissive to hand spinning. Of the colour cottons cultivated, brown and green are the most common ones. The recent investigations in brown cottons highlighted various positive features like higher lint yield, acceptable fibre quality, spinnability, colour stability, enhancement of single yarn strength and pigmentation on scouring and mercerization. These inventions further expanded the utility and application of colour linted cotton for bed linen, furnishings and other variegated consumer goods as well as household textiles.

Thus, naturally colour linted cotton forms the basic raw material to the handloom sector because of its fibre length, which is ultimately spun into coarser and uneven yarns. Further, naturally colour linted cotton may be blended with other natural and man-made fibres to produce blended and union fabrics. The utilization of these colour cotton yarns in producing blended and union fabrics are eco-friendly since they avoid artificial dyeing that avert the contamination of environment, pollution and health hazards.

Cotton in its pure form and with blends is the principal textile fibre of the universe. Millions of people depend on cotton cultivation because it meets the basic necessity of mankind and is known for its diversity, enormous utility, applicability, economic viability and advantageous properties. Of the 35 million hectares of land used for cotton cultivation globally, only 0.02 per cent is used for cultivation of coloured

Table A : Fabric information of the union fabrics

Sr. No.	Fabric samples	Fibre content		Yarn count		Cloth count	
		Warp	Weft	Warp	Weft	Ends/ inch	Picks/ inch
1.	Control (white cotton, WC)	White cotton	White cotton	2/40s	20s	56	56
2.	White cotton x DDCC-1 (WCD_1)	White cotton	DDCC-1	2/40s	24s	55	42
3.	White cotton x DBH-250 (WCD_2)	White cotton	DBH-250	2/40s	24s	56	46
4.	Control (Muga, MU)	Muga	Muga	65 d	65 d	72	70
5.	Muga x DDCC-1 (MUD_1)	Muga	DDCC-1	65 d	24s	72	46
6.	Muga x BH-250 (MUD_2)	Muga	DBH-250	65 d	24s	72	48
7.	Tasar (Control, TA)	Tasar	Tasar	75 d	75 d	72	70
8.	Tasar x DDCC-1 (TAD_1)	Tasar	DDCC-1	75 d	24s	71	48
9.	Tasar x DBH-250 (TAD_2)	Tasar	DBH-250	75 d	24s	72	50

cotton. Besides sustaining the country's textile industry, it earns precious foreign exchange by way of export both yarn as well as finished goods.

Naturally colour linted cotton can be blended with synthetic fibres to overcome the undesirable and to impart desirable properties in the spun yarn, which is short to produce the blended and union fabrics. Since ages these blended and union fabrics are popular as blending is more likely to produce results superior to those obtained from single fibre alone. The handspun naturally colour linted cotton yarn with unequal distribution of slubs and snarls in the yarn gives a fancy appearance and texture to the ultimate fabric that can go as designer's fabrics. Thus, to produce unique and eco-friendly fabrics economically, an effort was made to interweave naturally coloured cotton with white cotton and filature silks (Muga and Tasar) to produce union fabrics.

Objectives:

– To explore the possibility of utilizing naturally colour linted cotton yarns with white cotton, Muga and Tasar silk to produce union fabrics.

– To assess the performance of these eco-friendly union fabrics by kawabata evaluation system.

■ RESEARCH METHODS

Two brown varieties of naturally colour linted cotton *viz.,* Dharwad desi coloured cotton – 1 (DDCC-1) and Dharwad brown hirsutum – 250 (DBH –250), procured from Agricultural Research Station, Dharwad farm, Dharwad were hand spun, scoured and sized and were used as weft with white cotton and filature silks (Muga and Tasar) to produce union fabrics. The detail on fabric information is given in Table A. A total of six union fabrics with three control samples were used to assess the low stress mechanical properties using kawabata evaluation system fabric (KES-FB) system. From the low stress mechanical properties, the fabrics were rated for primary hand value (HV) and total hand value (THV) in order to evaluate the suitability of the fabrics for women's winter thin dress and women's winter suit.

Fabric handle is a terminology expressing the character and quality of a fabric as manifested by its performance in respect of fitting to human body, the feel of the surface and comfort in wearing. Traditionally the fabric handle assessment is done subjectively by the sensory perception of touch. KES-FB (Kawabata Evaluation System for fabrics) system has been developed to measure the basic mechanical properties of the fabric under low stress conditions in order to assess the objective evaluation of fabric feel and handle. Instead of the touch and feel by hand, the mechanical properties are measured and translated into primary hand value (HV) and to the total hand value (THV) as expressed by the appropriate conversion equations derived by means of statistical analysis of experts judgments using multivariable linear equations by Kawabata and Niwa with the co-operation of HESC (Hand Evaluation and Standardization Committee) in Japan. This system known as Kawabata Evaluation System (KES-FB) consists of four instruments to measure the fabric tensile/shear, bending, compression and surface properties. In other words the KES–FB objectively measures the hand properties *i.e.*, the instruments the measure mechanical properties that correspond to the fundamental deformation of fabrics in hand manipulation. The low stress mechanical properties of the fabric were measured by KES-FB system in standard atmosphere of 65 per cent RH and 27^0 C (Table 1).

■ RESEARCH FINDINGS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Tensile properties:

Tensile test measures the stress / strain parameters at the maximum load set for the material being tested (0% - completely inelastic and 100% - completely elastic). Of the union fabrics, Muga X DBH-250 (MUD_2, 7.86%) possessed higher extensibility followed by White cotton X DBH-250 (WCD_2, 7.59%) while the fabric extensibility (EMT %) was found to be higher in white cotton (WC, 7.19%) control sample followed by in tasar (TA, 4.19). Higher values indicated a stretchable material. However, fabric extensibility of union fabrics was higher compared to their respective control samples which revealed that union fabrics were more elastic than control samples (Table 1).

The tensile linearity (LT) was greater in muga (MU, 0.78) control fabric and was lower for white cotton (control) and union fabrics. The higher value of LT indicated greater linearity. Thus, filature silk fabrics have higher tenacity than white cotton fabrics.

Among the union fabrics, the greater value of tensile energy (WT, gf/cm/cm^2) was observed in muga X DBH-250 (MUD_2, 14.77 gf/cm/cm^2) followed by in muga X DDCC-1 (MUD_1, 13.15 gf/cm/cm^2), tasar X DDCC-1 (TAD_1, 12.34 gf/cm/cm^2) and white cotton X DBH-250 (WCD_2, 11.63 gf/cm/cm^2). However, tensile energy was greater in white cotton sample (control, 11.99 gf/cm/cm^2) than filature silk control samples. However, the tensile energy was greater in union fabrics than their respective control samples which revealed union fabrics to be stretchable and elastic in their tensile deformation than their respective control samples (Table 2).

The tensile resiliency (RT %) indicates the recovery of deformation from strain or ability to recover from stretching. It was found that, the tensile resiliency (RT %) was greater in filature silk control samples (MU- 70.26%, and TA-57.91%) than white cotton control sample (WC – 44.94%). However, among the union fabrics, the RT% was higher in tasar X DBH-250 (TAD_2, 48.25%), muga X DBH-250 (MUD_2, 45.90) and white cotton X DBH-250 (WCD_2, 45.25%). This revealed that the control samples had greater recovery from having been stretched than union fabrics and also among DDCC-1 and DBH-250 interwoven fabrics, DBH-250 interwoven fabrics had greater recovery from having been stretched (Table 2).

Bending properties:

Bending is a measure of force required to bend the fabric approximately 150^0. Table 2 shows that the bending rigidity (B) and hysteresis of bending (2HB) was higher in filature silk control and union fabrics and hence, indicated that these fabrics had greater stiffness / resistance to bending motions compared to white cotton control and union fabrics. The higher value of B and 2HB was found in white cotton (WC, 0.061 gf/cm/cm) among control fabrics and muga X DDCC-1 (MUD_1, B - 0.26 gf/cm/cm, 2HB - 0.198 gf/cm/cm) among union fabrics. Hence, DDCC-1 interlaced fabrics are stiffer or resistance to bending motions compared to DBH-250 fabrics.

Shear properties:

Shear stiffness is the ease with which the fibres slide against each other resulting in soft / pliable to stiff / rigid structures. It is found from Table 2 that, the shear stiffness (G) and hysteresis of stiffness (2HG) was higher in white cotton control sample (0.95 gf.c.deg. and 2.33 gf/cm) compared to filature silk control fabrics. However, white cotton x DDCC-1 (WCD_1), muga x DDCC-1 (MUD_1) and tasar x DBH-250 (TAD_2) showed higher values of shear stiffness and hysteresis of stiffness. This may be due to the compact structure of the

Table 1: Mechanical properties of the fabric samples

Sr. No.	Mechanical properties	Fabric samples								
		WC	WCD_1	WCD_2	MU	MUD_1	MUD_2	TA	TAD_1	TAD_2
Tensile properties										
1.	Fabric Extensibility (EMT%)	7.19	7.24	7.59	2.91	6.78	7.86	4.19	7.20	5.60
2.	Tensile linearity (LT)	0.659	0.634	0.631	0.780	0.752	0.752	0.756	0.72	0.661
3.	Tensile energy (WT, gf/cm/cm^2)	11.99	11.16	11.63	5.67	13.15	14.77	8.02	12.34	9.20
4.	Tensile resiliency (RT%)	44.94	41.83	45.25	70.26	41.55	45.90	57.91	42.16	48.25
Bending properties										
1.	Bending rigidity (B, gf/cm/cm)	0.054	0.102	0.10	0.129	0.257	0.177	0.114	0.12	0.122
2.	Hysteresis of bending (2HB, gf/cm/cm)	0.061	0.107	0.088	0.039	0.198	0.125	0.041	0.15	0.095
Shear properties										
1.	Shear stiffness (G, gf.c.deg.)	0.95	0.86	0.71	0.35	0.81	0.74	0.37	0.53	0.80
2.	Hysteresis of stiffness (2HG, gf/cm)	2.33	2.17	2.19	0.70	1.56	1.54	0.84	1.48	1.51
Compressional properties										
1.	Linearity of compression (LC)	0.292	0.337	0.335	0.434	0.349	0.330	0.236	0.37	0.336
2.	Compressional resiliency (RC%)	35.21	43.24	43.50	64.98	40.01	44.45	75.10	45.45	43.12
Surface properties										
1.	Co-efficient of friction (MIU)	0.204	0.228	0.225	0.152	0.18	0.178	0.126	0.19	0.185
2.	Geometrical roughness (SMD µm)	9.768	14.574	13.992	7.350	17.004	15.532	5.864	18.58	7.164

fabric and higher flexural rigidity.

Compressional properties:

The linearity of compression (LC) curve was found to be higher in muga (MU, 0.434) followed by in white cotton (WC, 0.29) control fabric while the lower value was observed in tasar (TA, 0.236). Among the union fabrics, a higher value of LC was observed in tasar x DDCC-1 (TAD_1, 0.368) fabric. However, the compressional resilience (RC %) was higher in control fabrics than their corresponding union fabrics that indicated high per cent recovery from being compressed.

Surface properties:

The co-efficient of friction (MIU) was higher in union fabrics compared to their respective control samples which revealed that union fabrics had more contact area with that of body. Also higher MIU value corresponds to greater friction or resistance and drag. However, white cotton x DDCC-1 (WCD_1, 0.228) and white cotton x DBH-250 (WCD_2, 0.225) possessed higher values of MIU. It was further observed that geometrical roughness (SMD) was higher in union fabrics than their respective control samples *i.e.*, higher SMD corresponds to geometrically rougher surface. However, the higher SMD was noticed in tasar x DDCC-1 (TAD_1, 18.58) followed by in Muga x DDCC-1 (MUD_1, 17.004µm) fabric (Table 2).

Further, these low stress mechanical properties were translated into primary hand values (HV) and to the total hand values (THV) to characterize these fabrics for women's winter thin dress and women's winter suit. The primary hands used to characterize women's winter thin dress were *Koshi* (stiffness), *Numeri* (smoothness) and *Fukurami* (fullness and softness) whereas, the Primary Hands used to characterize women's winter suit were *Koshi* (stiffness), *Numeri* (smoothness), *Fukurami* (fullness and softness) and *Sofutosa* (softness). These Primary Hands are rated numerically on a scale from 0 (weak) to 10 (strong) and the Total Hand Value is rated from 1 (poor) to 5 (excellent).

Table 2 shows the primary hand and total hand values of the fabric samples for women's winter thin dress and reveals that, all the fabrics were rated above 5 for *Koshi* (stiffness) indicating that these fabrics are medium to strongly stiffer. However, higher value of *Koshi* was observed in Muga x DDCC-1 (MUD_1, 7.05) fabric followed by Tasar x DDCC-1 (TAD_1, 6.76) fabric. Among the control fabrics, Muga (MU, 6.27) showed higher value of *Koshi* (stiffness). The *Numeri* (smoothness) value was found to be higher in Tasar (TA, 6.95) followed by in Muga (MU, 6.21) fabric. *Fukurami* (Fullness and softness) was higher in Tasar (TA, 9.68) control fabric and white cotton

Table 2 : Primary hand and total hand values (THV) for women's winter thin dress

Sr. No.	Fabric samples	*Koshi* (Stiffness)	*Numeri* (smoothness)	*Fukurami* (fullness and softness)	THV
1.	Control (White cotton, WC)	5.86	5.90	9.39	4.25
2.	White cotton x DDCC-1 (WCD_1)	6.43	5.58	9.24	3.98
3.	White cotton x DBH-250 (WCD_2)	6.25	5.41	9.19	3.97
4.	Muga (Control, MU)	6.27	6.21	8.90	4.18
5.	Muga x DDCC-1 (MUD_1)	7.05	5.04	8.87	3.43
6.	Muga x BH-250 (MUD_2)	5.83	5.03	8.82	3.83
7.	Tasar (Control, TA)	6.09	6.95	9.68	4.73
8.	Tasar x DDCC-1 (TAD_1)	6.76	2.24	6.71	2.84
9.	Tasar x DBH-250 (TAD_2)	6.05	3.48	8.48	3.46

Table 3: Primary hand and total hand values (THV) for women's winter suit

Sr. No.	Fabric samples	*Koshi* (Stiffness)	*Numeri* (Smoothness)	*Fukurami* (fullness and softness)	Sofutosa (Softness)	THV
1.	Control (White cotton, WC)	4.21	3.27	4.46	2.20	2.44
2.	White cotton x DDCC-1 (WCD_1)	4.98	2.93	4.27	2.19	2.48
3.	White cotton x DBH-250 (WCD_2)	4.74	2.74	4.22	1.97	2.40
4.	Muga (Control, MU)	4.79	3.51	3.60	2.23	2.42
5.	Muga x DDCC-1 (MUD_1)	4.84	2.33	3.99	1.19	2.43
6.	Muga x BH-250 (MUD_2)	4.14	2.30	3.85	1.43	2.14
7.	Tasar (Control, TA)	4.54	3.98	4.05	3.24	2.61
8.	Tasar x DDCC-1 (TAD_1)	5.37	-0.81	1.44	-1.41	1.61
9.	Tasar x DBH-250 (TAD_2)	4.63	0.67	3.41	-2.09	2.07

x DDCC-1 (WCD_1, 9.24) union fabric. However, the rated values were above 6 for *Fukurami* revealing that these fabrics are medium to strong in fullness and softness. It was observed from this table that, *Koshi* was found to be higher in DDCC-1 interwoven fabric whereas lower in *Numeri* and *Fukurami* revealing that these fabrics are stiffer than DBH-250 interwoven fabrics.

The total hand value (THV) among control fabrics was rated higher for tasar (TA, 4.73) fabric followed by for white cotton (WC, 4.25) and Muga (MU, 4.18) fabrics. Among union fabrics, White cotton x DDCC-1 (WCD_1, 3.98) and White cotton x DBH-250 (WCD_2, 3.97) were rated higher values thus, proving that these fabrics are excellent for women's winter thin dress. However, the total hand values were above 3 for rest of the union fabrics except in tasar x DDCC-1 (TAD_1, 2.84).

Table 3 illustrates the primary hand and total hand values of the fabric samples for women's winter suit and revealed that, the higher values of *Koshi* (stiffness) among union fabrics was noticed in Tasar x DDCC-1 (TAD_1, 5.37) which indicated that this fabric is medium to strongly stiffer. In rest of all the control and union fabrics the values of *Koshi* was found to be below 5 indicating that these fabrics are fairly stiff. The values of *Numeri* (smoothness) and sofutosa (softness) were found to be below 4 and *Fukurami* (fullness and softness) below 5 which revealed that these fabrics are slightly smooth and soft as well as medium in fullness and softness, respectively for women's winter suit. It is observed from this table that, *Koshi*, *Numeri* and *Fukurami* were found to be higher in DDCC-1 interwoven fabric than DBH-250 interwoven fabrics.

The total hand value (THV) among control fabrics was rated higher for tasar (TA, 2.61) fabric followed by for white cotton (WC, 2.44) and muga (MU, 2.42) fabric. Among union fabrics, white cotton x DDCC-1 (WCD_1, 2.48) and muga x DDCC-1 (MUD_1, 2.43) were rated higher values. However, the total hand values were below 3 revealing that these fabrics are fairly suitable for women's winter suit.

Conclusion:

Objective evaluation of the naturally colour linted and filature silk union fabrics proved to be better in tensile, bending, shear, compressional and surface properties as well as the total hand value showed that these fabrics are excellent for women's winter thin dress. This reveals that the naturally colour linted brown cotton can be used as weft with filature silk for women's winter thin dress. Generally colour linted cotton is short staple, with low fibre strength compared to white cotton. Hence, it may be difficult to spin the colour cotton to finer counts to produce quality yarn with absolute uniformity. Thus, it forms the basic raw material to the handloom sector. The handspun yarn showed unequal distribution of slubs and snarls, an added advantage of fancy appearance and texture. These union fabrics are new and unique of its kind that avoids artificial dyeing and hence eco-friendly. Further, these fabrics are suitable for shirting's, dress materials, veils, scarves and also can go as a designer's fabric that definitely meets the fashion trends and sustains in both domestic and international market as well as supports the handloom sector. Further, more cultivation of naturally colour linted cotton on commercial scale not only forms an income generating activity for cotton cultivators, but also a source of livelihood for local spinners and weavers, thus positively supports the socio-economic status of the handloom weavers, the neglected sector of the weavers community. Datta and Patel (1995), Sharma *et al.* (2000) and Mukhopadhyay *et al.* (2002) have also made some observations related to the present investigation.

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