A detailed analysis on physical and comfort properties of bed linen woven fabrics

S.Sundaresan[1], M.Ramesh[2], V.Sabitha[3], M.Ramesh[4], V.Ramesh5
1. Assistant professor (SRG), Department of Textile Technology, Kumara Guru College of Technology, Coimbatore-641049, Tamil Nadu, India
2.3, 4: UG scholars, Department of textile technology, Kumara Guru College of technology, Coimbatore-641049, Tamil Nadu, India,
5. AGM(sales and Marketing) Grasim fibres(Adithya Birla Group), Erode

ABSTRACT

The bed sheets used in home and hospital bedding are made of cotton or polyester cotton blended fabrics, which seems to date from the past centuries. But these home and hospital textiles need to ensure the comfort and hygienic level of the human and needs to be engineered with specific comfort properties. But no effort has been made to make new textile materials that could help in reducing the discomfort experienced by the human. Textile products are used in many sectors in various forms. It comprises of gowns, caps, masks, uniforms drapes, covers, beddings bed sheets, blankets, pillow cases etc. The complexity of applications has increased with research and developments in the area of bed linen materials. It is observed that for many products, ideal set of physical and chemical properties would not be possible to achieve from one fiber alone. Hence, blending of two or three fibers having differing physical and chemical properties for the desired product becomes essential. Bed linen is a sheet of material used to cover the bed, which should be soft with warm handle and easy care properties. The majority of the bed linen is made from cotton and polyester/cotton blended yarns. Depending on the end use, cost factor, durability of the textiles, comfort and aesthetic properties, the fiber choice is made from natural fiber, regenerated cellulosic fibers and synthetic fibers. The major requirement of a fabric sheet is to be comfortable, nice touch and durable to wear and easy care. Linen is also blended with other compatible natural and manmade fibres to achieve various structural and functional properties, and also to reduce costs. Fabrics produced from 100% linen and their blends with cotton and viscose have been studied for handle and comfort properties. Linen fabrics produce excellent aesthetic and drape properties. Linen fabrics are found to be tougher than cotton and other blends. However, linen offers the highest tensile resilience and the lowest friction coefficient under low stress-loading conditions. In this research work yarn made from cotton, lyocell, Modal and viscose were used with different combination to produce the woven fabric of plain weave structure. The fabric thus produced is bleached and its physical properties like air permeability drape, tearing strength, water vapor permeability, electro static charge, tensile strength, low stress mechanical properties and total handle value has been tested. The findings of test results have been tabulated and the optimization of results has been done to find the best combination yarn to produce the bed linen fabrics.

Key words: *Bed linen, Woven structure, Water vapor permeability, Air permeability, Drape, Low stress mechanical properties, total handle value (THV), Electro static charge.*

1 Introduction:

The bed sheets used in home and hospital bedding are made of cotton or polyester cotton blended fabrics, which seems to date from the past centuries. Textile products are used in many sectors in various forms. It comprises of gowns, caps, masks, uniforms drapes, covers, beddings bed sheets, blankets, pillow cases etc. The complexity of applications has increased with research and developments in the area of bed linen materials. . Fabrics produced from 100% linen and their blends with cotton and viscose have been studied for handle and comfort properties. Linen fabrics produce excellent aesthetic and drape properties. Linen fabrics are found to be tougher than cotton and other blends. However, linen offers the highest tensile resilience and the lowest friction coefficient under low stress-loading conditions. From literature review cited the following information has been obtained about bed linen materials.

Compared to the other two fibers, lyocell features the highest moisture absorption rate: with air humidity at 65 %, lyocell still has unused capacity to absorb moisture from the skin. compares the surface structure of lyocell

and cotton fibers. Lyocell fiber has an extremely smooth surface and feels soft and pleasant on the skin[1]. The combination of a smooth fiber surface and excellent moisture absorption creates a positive environment for healthy skin, making lyocell ideal even for anyone with sensitive skin. According to recent dermatological studies, wearing clothing made of lyocell significantly improves comfort and promotes a feeling of well being[2] . The comfort properties of single layered and double layered fabrics made of tencel/ polyester blended yarns in the face of the fabric and polyester as the skin contact layer. From the experimental results the authors concluded that tencel can be used effectively for the development of high performance sportswear provided that the fabric is carefully designed to maximize the contribution of the tencel to the performance of the fabric [3]. Comparative analysis of thermal insulation properties of fabrics made of cotton and tencel with different weave structures. The fabrics made of tencel yarn showed lower values of thermal conductivity and thermal absorption and also higher values of thermal diffusion and resistance than fabrics made of cotton yarns [4]. Role of fiber properties on comfort characteristics of fabric and studied how the blending of fibers at yarn manufacturing stage can lead to fabrics having the desired characteristics from comfort point of view. Air permeability increases with increase in polyester content and the water vapour transmission rate also increased with the air flow rate of the above fabric[5]. Thermal transport properties of a series of polyester, cotton and polyester/cotton blended fabric in an effort to understand the physical basis of clothing comfort. The results indicated that both the fabric construction and the constituent fiber properties affect thermal comfort[6]. Effect of polyester content, pick density and weave on the thermal comfort and tactile properties of polyester/ viscose blended yarn fabrics for suiting, by measuring the low stress mechanical properties on Kawabata evaluation system and reported that increasing polyester content increased fabric hand but decreased fabric smoothness, softness, fullness and total hand value and increased thermal insulation and water vapour resistance[7]. The handle and comfort properties of fabrics made of 100% linen and their blends with cotton and viscose, and reported that total hand value (THV) of linen fabric is higher than that of cotton fabric and blending of viscose and cotton improves the hand value of linen fabric [8]. The dynamic moisture absorption behavior of polyester/cotton fabrics of different warp and weft densities, and the results showed that the fabric moisture absorption velocity is in reverse relation with its warp and weft densities [9]. For getting thermo physiological comfort the clothing should have suitable thermal conducting properties as well as sufficient permeability to water vapour and / or sufficient level of ventilation [10]. The overall comfort of an apparel fabric depends on the proper combination of values for pore size, air permeability, water vapour permeability, thermal insulation, surface contact with skin and several other fabric properties [11]. The air permeability increased with the increase of porosity of the fabric or decrease of its thickness [12]. The type of finish given to a fabric can have a considerable effect on the permeability even though the porosity may remain the same [13]. Cover factor combines fabric count and yarn size to give an indication of fabric structural properties that contribute to thermal comfort [14]. **T**he moisture transmission behavior of a clothing assembly plays a very important role in influencing its efficiency with respect to thermo physiological body comfort [15]. Measurement of water vapour transmission of fibers independent of any air space surrounding the fibers, by using sections cut from embodiments of the fibers in polyacrylic resins [16]. Analysis of the frictional characteristics of woven suiting and shirting fabrics with different blends, construction parameters and found that the fabric to metal friction is less sensitive to fabric morphology and rub direction, whereas the fabric to fabric friction is highly sensitive to the type of fiber, blend, yarn structure, fabric structure, crimp, compression etc. For all fabrics kinetic friction is always lower than static friction of different levels[17]. For comfort properties of textiles with varying end use applications, in the normal textile sector, technical textiles and other fields, moisture management play a key role [18]. Optimization of the thermal comfort properties of bed linen using different commercial softeners often used in home textiles finishing. The thermal related properties are influenced by polyethylene softener [19].

2. Materials and methods

The bed linen fabric has been developed the by using different combination of yarns in both warp and weft direction. For producing the woven fabric yarn made up of cotton Lyocell modal viscose has been used, The fabric has been produced using the different combination of yarn in warp and weft. Plain weave used for producing the bed linen fabric. The fabric produced has been bleached and the physical properties and comfort properties has been tested.

The following (Table-1) (Table -2) will give the material particulars used to produce bed linen fabric.

Table -1 : Materials used

S.NO	TYPE OF YARN	COUNT
1	Cotton	40s
2	Lyocell	40s
3	Viscose	40s
4	Modal	40s
5	Polyester	30s

Table -2 Fabric construction details

Weave : plain weave

S.NO	WARP	WEFT
A	Cotton	Cotton
B	Cotton	Modal
C	Cotton	Lyocell
D	Cotton	Viscose
E	Cotton	Polyester

3.Results and discussion

The table -3 shows the yarn and fabric parameters here we compare the parameters with different kind of sample.

Table-3 Basic fabric particulars

S.NO	SAMPLE	YARN COUNT	EPI	PPI	GSM	THICKNESS (mm)
1	A	40s	58	58	127.2	0.57
2	B	40s	60	60	121.2	0.57
3	C	40s	55	55	120.4	0.53
4	D	40s	62	62	121.8	0.52
5	E	30s	85	78	124.8	0.63

The sample has been produced by using cotton yarn as warp for all the fabric. The EPI, PPI has been kept constant for all the samples

Table-4 **Physical Properties of Bed Linen Fabric**

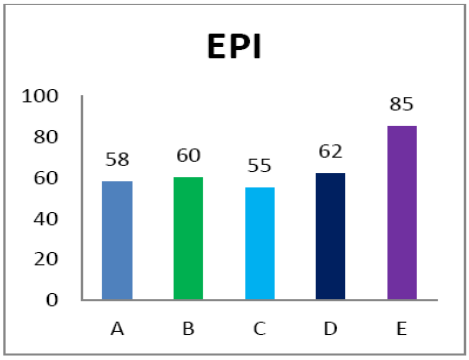
SAMPLE	DRAPE (f)	AIR PERMEABILITY ($cm^3/cm^2/sec$)	TEARING STRENGTH (lbs.)	CREASE RECOVERY		WATER VAPOUR PERMEABILITY	ELECTRO STATIC CHARGE
				Warp	Weft	($g/m^2/day$)	(kv)
A	0.57	22.83	255	74	70	2548.935	2.75
B	0.57	22.83	224	80	70	2516.955	1.82
C	0.54	24.67	228	71	68	2535.912	2.56
D	0.53	25.41	235	93	71	2542.936	3.65
E	0.6	5.55	325	65	58	2159.924	2.15

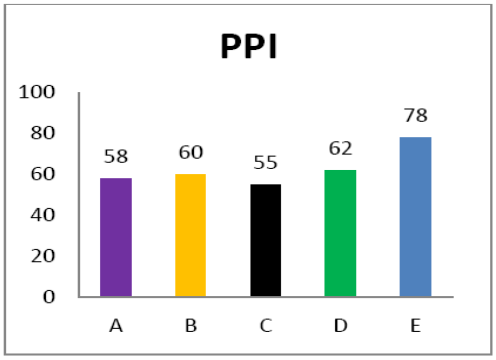
Table 4 illustrate the Physical Properties of Bed Linen Fabric

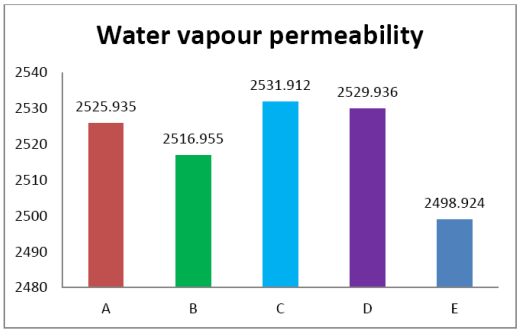
3.1Tensile Testing

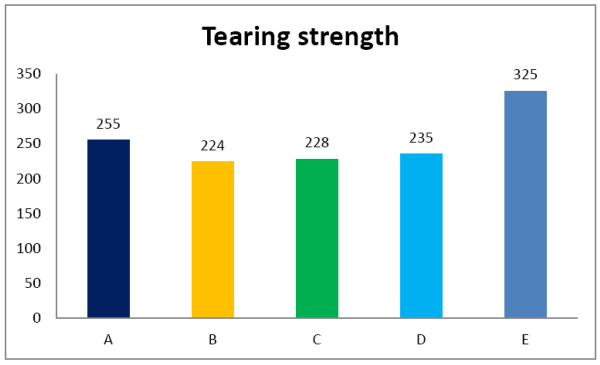
Table-5 Tensile strength

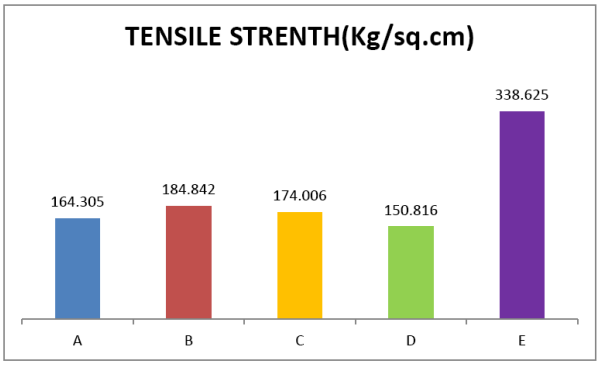
SAMPLE	C.S.A(sq.cm)	PEAK LOAD (kg)	TENSILE STRENTH(Kg/sq.cm)	ELONGATION (%)
A	0.1400	23.011	164.305	13.459
B	0.1225	22.612	184.842	13.659
C	0.1175	20.452	174.006	14.325
D	0.1225	18.472	150.816	12.593
E	0.0725	24.553	338.625	27.761

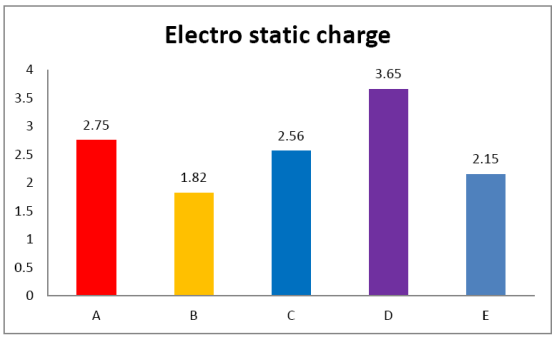


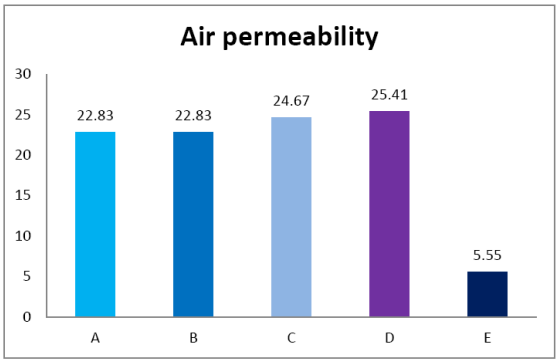












A- Cotton *cotton B- Cotton *Modal C- Cotton * Lyocell

D- Cotton * Viscose E- Cotton*Polyester

Sample code and explanation

Figure 1: Bar chart showing the physical properties of bed linen fabric

From above results the sample produced from cotton-cotton, cotton-modal cotton-lyocel, cotton-viscose has not shown any significant difference in their physical properties.

3.2 Characteristics of Low Stress Mechanical Properties

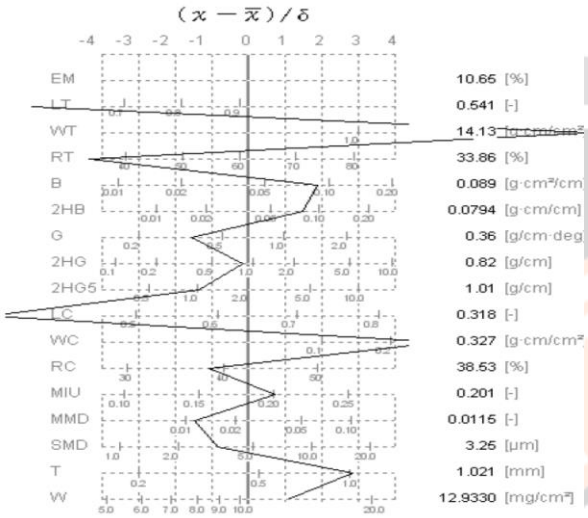
Table-6 **Low Stress Mechanical Properties**

PARAMETEES	A	B	C	D
Tensile EM (%)	10.65	7.99	8.54	7.50
LT(-)	0.541	0.465	0.467	0.513
WT(g.cm/cm²)	14.13	9.07	9.82	9.02
RT (%)	33.86	42.32	40.83	43.54
Bending B (g.cm²/cm)	0.089	0.066	0.067	0.069
2HB (g/cm)	0.0794	0.0562	0.0523	0.0731
Shear G(g/deg)	0.36	0.29	0.27	0.29
2HG(g/cm)	0.82	0.41	0.41	0.40
2HG5(g/cm)	1.01	0.47	0.46	0.47
Surface MIU(-)	0.201	0.192	0.179	0.177
MMD(-)	0.0115	0.0154	0.0148	0.0099
SMD(m)	3.25	5.13	4.57	5.23
Compression LC(-)	0.318	0.331	0.317	0.292
WC (g.cm/cm²)	0.327	0.315	0.306	0.296
RC (%)	38.53	41.59	42.48	42.23

T & W	T(mm)	1.021	0.928	0.957	0.947
	W(mg/cm²)	12.9330	12.1660	12.6570	12.7130

3.3 KES-FS Mechanical data chart

Fabric A



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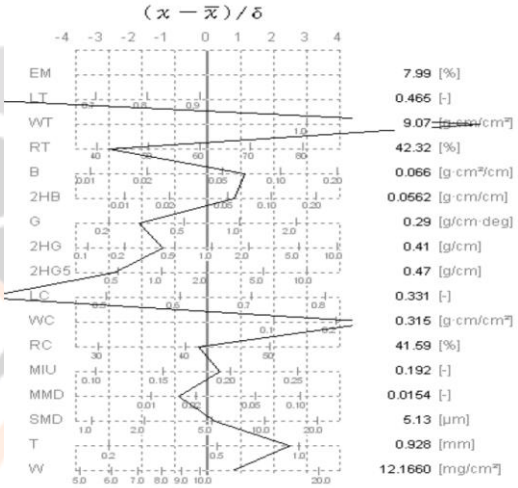
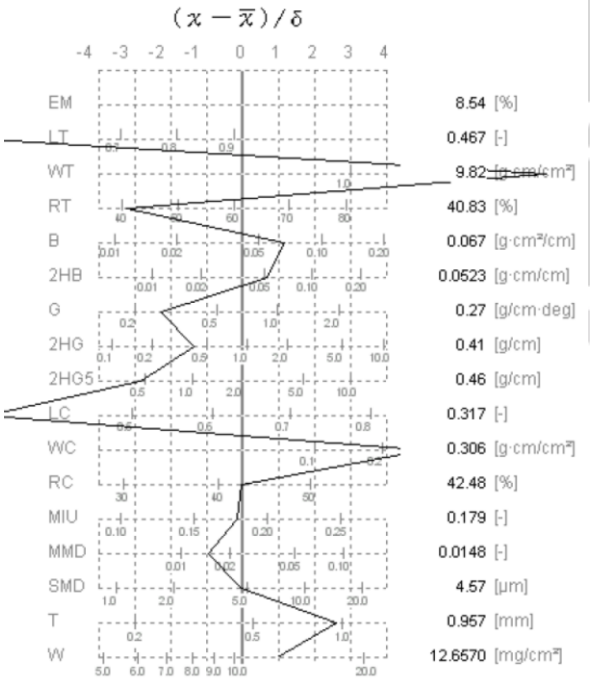


Fabric C



Fabric D

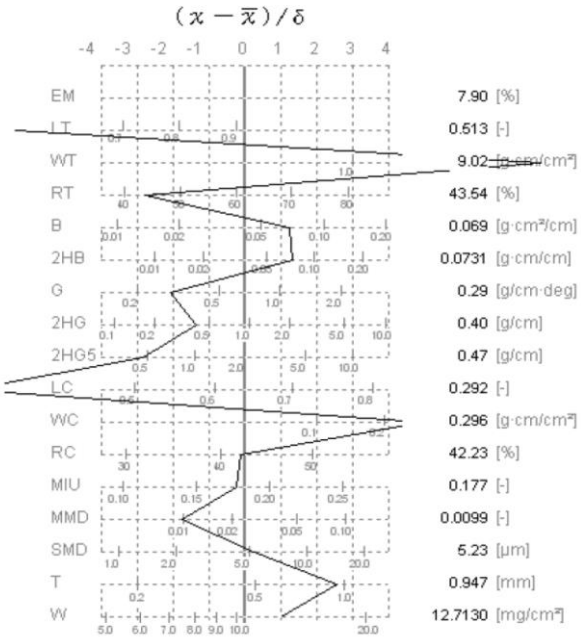


Figure – 2 KES-FS Mechanical data chart

3.4 Total Hand Values (THV) of bed linen fabrics

Table- 7 Total Hand Values (THV)

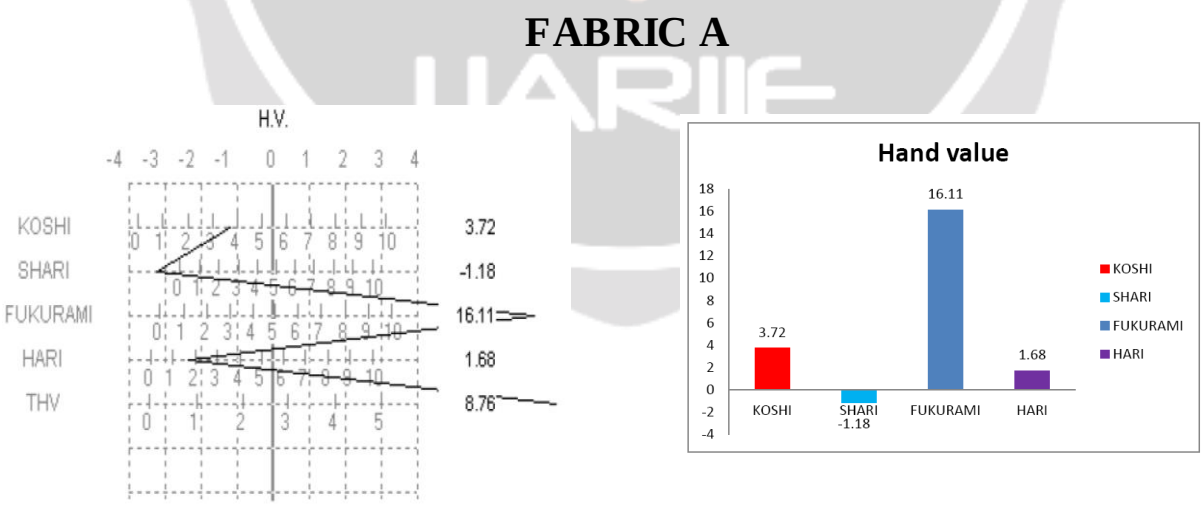
Sample	H.V				T.H.V
	KOSHI	SHARI	FUKURAMI	HARI	
A	3.72	-1.18	16.11	1.68	8.76
B	2.87	-0.65	16.17	-0.50	8.49
C	2.74	-0.95	16.49	-0.52	8.70
D	2.90	-0.58	16.13	-0.41	8.47

H.V- Hand value	Grading
10	**Strong**
1	**Weak**
THV	
5	**Excellent.**
1	**Poor**

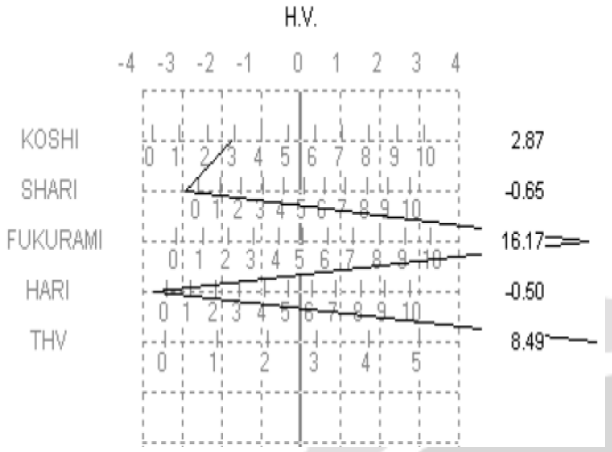
The primary total hand value is higher for the cotton/cotton (A) compared to other two bed linen fabric (B, D), except sample (C) it is have same level of total hand value to the cotton/cotton bed linen. The Value of SHARI is high for the sample (E) compared to the other two sample (B, D) and lower than the first sample. Other hand value parameters are nearly same range for sample (B, C, and D) and KOSHI value is high for the cotton/cotton bed linen.

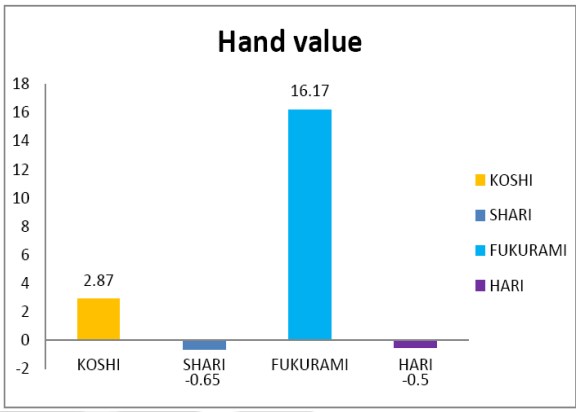
3.5 HAND VALUE DATA CHART

Figure: 3 HAND VALUE DATA CHART

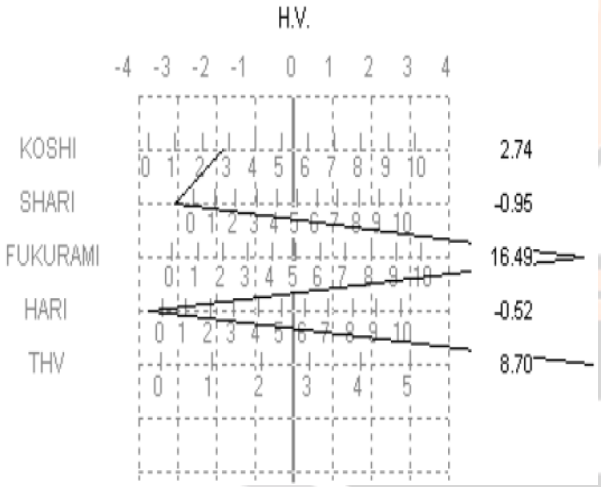


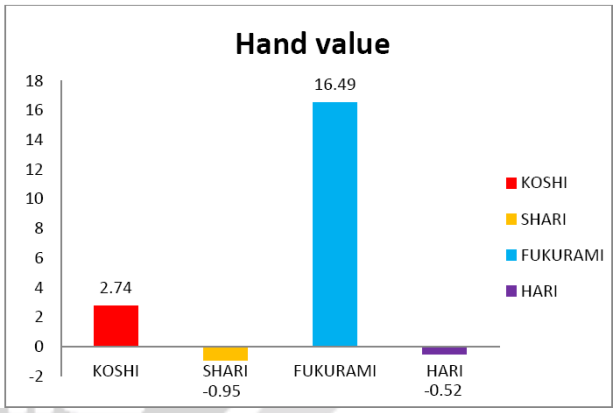
FABRIC –B





FABRIC –C





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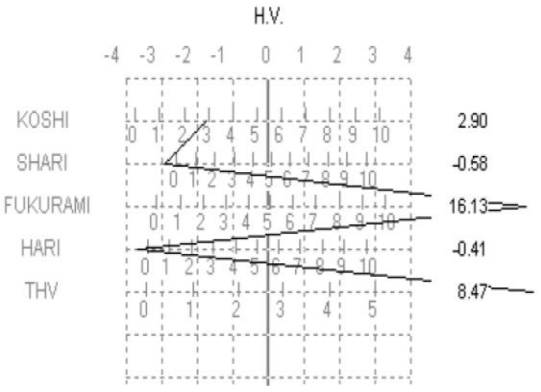

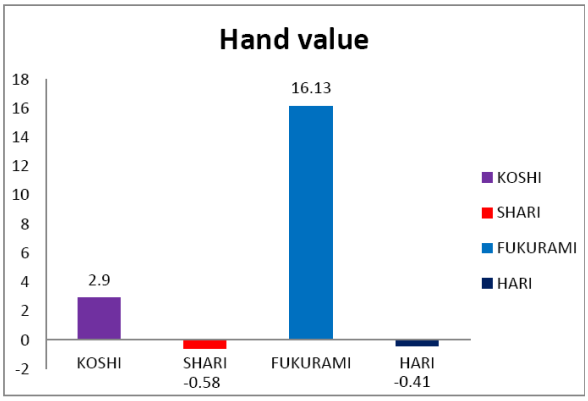

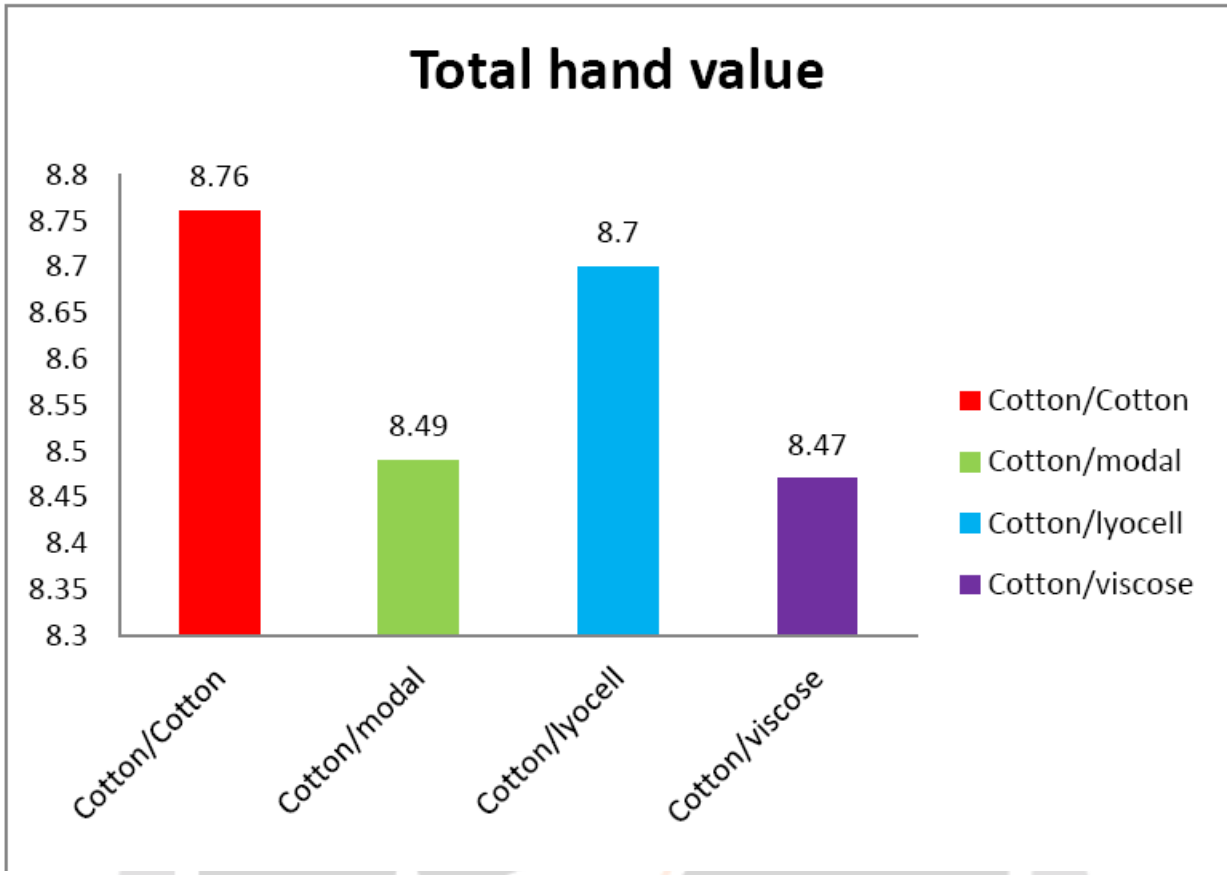

The total handle value of bed linen fabric made from the cotton yarn as warp and weft shows highest value when compared to other fabrics.

Conclusion:

The bed linen fabric made from cotton shows a better result in terms of comfort properties and physical properties. The fabric made from the combination of cotton warp and lyocell weft also shows a better results in terms of physicalproperties and comfort properties. The fabrics made from the combination of cotton-modal and cotton viscose shows moderate results compared to the fabric made from cotton warp and wet cotton warp and lyocell weft. Hence it has been concluded that the fabric produced from the cotton warp and weft, cotton warp and lyocell weft has a significant improvement in all manner and is best suited for making bed linen.

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