International Conference on Systems, Science, Control, Communication, Engineering and Technology 2016 [ICSSCCET 2016]

ISBN	978-81-929866-6-1
Website	icssccet.org
Received	25 – February – 2016
Article ID	ICSSCCET200

VOL	02
eMail	icssccet@asdf.res.in
Accepted	10 - March – 2016
eAID	ICSSCCET.2016.200

ERI Silk for Functional Knitted Apparels

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Abstract: *Man is always curious for silk products. Silk is the queen of textile gives luxury, elegance, comfort. Silk has properties like the natural sheen, inherent affinity for dyes and high absorbance, warmth, light weight, resilience. Silk knitted fabric is a new avenue in the international market, produced from both Mulberry and Non-Mulberry silk varieties. Eri silk knitted fabrics are natural, ahimsa, eco-friendly and glamorous. These knitted fabrics have better physical, dimensional, thermal and moisture management properties which evidence that the fabric is suitable for suitable for both summer and winter wear. These silk knitted garments inspire and stimulate the creative minds of the fashion world and it has added one more aspect to the range silk products. This paper reveals the various process parameters of silk fabric production, physical, dimensional and comfort characteristics of developed fabrics.*

Keywords: *Eri silk, linear density, dimensional properties, Physical properties, moisture management capacity*

1. INTRODUCTION

India is the only country in the global producing all four silk varieties, Mulberry, Tasar, Eri and Muga. Mulberry silk is produced on larger scale as a commercial venture, the other varieties of silks Tasar, Eri and Muga are produced mainly by the tribal people inhabiting the forests. Hence these silks are popularly known as *Vanya Silks*. Mulberry, Tasar and Muga cocoons are reelable to produce filament. Eri cocoons are mouth opened and not suitable for reeling, possible to manufacture only as spun yarn. Since these silk can be taken out without killing the pupae, it can be promoted as Ahimsa (non violent) silk. The Eri mill spun yarn can produce from worsted system of spinning. The yarn count ranges from $2/10^s$ Nm to $2/140^s$ Nm. Sustainable eco-textile for both consumerist and manufacturer satisfaction and well being are the need for today. By considering the above facts and the positive role of value added products and need of organic-eco friendly knitted garments in the fashion world, the process parameters, physical, dimensional and moisture management characteristics were studied, by using the suitable yarn count for circular weft knitting machines.

2. Materials and Methodology

2.1 Materials

Eri silk yarn with linear density of $2/100^s$Nm, $2/120^s$ Nm & $2/140^s$ Nm were used to produce single and Double Jersey knit structures. The yarn are degummed ad residual the yarn specifications used for the development is given in the table.

Characteristics	Actual Value		
Yarn count (IS1315:1977)	**2/100s Nm**	**2/120s Nm**	**2/140s Nm**
Count CV%	3.5%	4.2%	4.0%

Cite this article as: B Senthil Kumar, T Ramachandran. "ERI Silk for Functional Knitted Apparels". *International Conference on Systems, Science, Control, Communication, Engineering and Technology 2016*: 968-972. Print.

CSP	2900	3350	3300
Single Yarn strength	397gms	347gms	360gms
Mean elongation	11.9	12.2	13.4
Tenacity (RKM)	15.2	15.0	14.8
U% (ASTM D 1425 M:09)	10.8	11.2	11.0
Total Imperfection	93	82	85
Thin (-50%)	21	12	16
Thick (+50%)	30	32	32
Neps(+200%)	42	38	37
Hairiness index	4.62	4.22	4.85

Table – 1– Eri Yarn Specifications

2.2 Fabric Development

2.2.1 Knitting

Knitting is one of the main aspects of the developmental work. To improve the knitting performance the following care has been taken during knitting.

1. To improve the flexibility as well as bendability of the yarn wax winding was done.
2. Optimum machine gauge and 10% more stitch length than cotton yarn were maintained.
3. Yarn feeding and the take-up tension were reduced less than 3 CN.

The Specification of knitting machine on which the fabric samples produced is given below.

Machine Particulars	Machine Values			
Type of Machine	Single Jersey		Double Jersey	
Fabric Structure	Plain	Pique	Rib	Interlock
Make	Pailung	Pailung	Terrot	Pailung
Dia (inches)	24	24	30	30
Gauge	24	24	14	22
Feeders	72	72	56	54
Cam tracks	4	4	4	4
Speed (RPM)	28	28	16	20

Table –2 – Machine details

2.3 Wet Processing of Fabrics

Dyeing was done in a bath having material to liquor ratio of 1:10 with different dye concentrations in an automated Soft flow Dyeing machines. The dye manufacturers' recommended processes were followed. The dyed fabrics were washed with normal water, rinsed and then dried. The P^H of dye bath was maintained with acetic acid and sodium carbonate.

To improve the handle feel of the fabrics, the dyed fabric treated (Finishing) with 2 to3% Non Ionic silicon softener (SKI) on weight of material using tubular Pad- dryer machine. Subsequently curing was done at 140°C for 2.5 min in relax dryer machine.

2.4 Compacting

Compacting is a mechanical finishing process carried out to bring the fabric into dimensionally equilibrium state. Compacting is done with "Tube Tex" compaction calendar machine at 110° C. The fabric is stretched width wise it's over feed lengthwise. Then it shrunk in length wise in the compressive shrinkage unit.

2.5 Evaluation of Physical Parameters of Fabric

The fabrics were measured for the stitch length (loop length), aerial density (GSM) and fabric thickness with the help of Shirley thickness gauge. The fabric structural and physical fabric properties were evaluated according to following standards ; aerial density (ASTM D 3776), thickness (ASTM D 1777), Bursting Strength (ASTM D 3786) wales and courses per unit length (ASTM D 3887:

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1996) and loop length (ASTM D 3887) . The aerial density of the knitted fabrics was measured by cutting the sample size of 10cm x 10cm. The sample was weighed in the electronic balance and the value was multiplied by 100. The loop length was derived by unravelling 10 courses and their total length was measured. The average loop length was determined using the formula i.e. total length x no. of wales/10. The air permeability tests were conducted according to the ASTM D737-04(2008)e2 by using the Tex-test FX 3300 Air permeability tester at a pressure drop of 100 Pa (20 cm^2 test area).

2.6 Evaluation of Dimensional Properties of Fabric

In order to determine the effect of repeated washing on area shrinkage of fabrics, IFB front loading washing machine (5 kg capacity) with gentle action were used for washing and flat drying was followed to all the knitted samples. The area shrinkage of fabric samples was tested as per AATCC 135.Fabric geometrical parameters were measured after every wash and flat dry.

2.7 Evaluation of Moisture Management Properties

According to AATCC test method 195-2009, Multi-directional moisture transport capabilities of fabrics can be measured by MMT test device. By using MMT device, Wetting time top & bottom layers of fabrics (WTt, WTb), absorption rate of top & bottom layers (ARt &ARb), max. wetted radius of top & bottom(MWRt & MWRb), spreading speed of liquid in top & bottom layers (SSt & SSb). Moisture Accumulative one-way transport capacity index (AOTI) and overall moisture management capability (OMMC) of fabrics were determined by liquid moisture transport properties in multi-directions.

In this experiment, all specimens (8.0 x 8.0 $\pm$ 0.1 cm^2) were washed and ironed to remove excess water and wrinkles. The samples were conditioned for 24h in the standard atmospheric temperature before to the testing. The indices are graded according to the AATCC 195-2009 test method and converted from number values to a grade on a five grade scale

Grading of Moisture management indices

Index	Grade				
	1	2	3	4	5
Wetting time top & bottom (WTt & WTb) – Sec	>120 No wetting	20-119 Slow	5-19 medium	3-5 Fast	<3 Very fast
Absorption rate top & bottom (ARt & ARb)- %/Sec	0-10 Very slow	10-30 Sslow	30-50 Medium	50-100 Fast	>100 Very fast
Max wetted radius top & bottom (MWRt & MWRb)- mm	0-7 No wetting	7-12 Small	12-17 Medium	17-22 large	>22 very large
Spreading speed top & bottom (SSt & SSb)- mm/sec	0-1 very slow	1-2 Slow	2-3 Medium	3-4 Fast	>4 Very fast
Accumulative one-way transport capacity index (AOTI) %	< -50 Poor	-50 to 100 Fair	100-200 Good	200-400 Very good	>400 Excellent
Overall moisture management capability (OMMC)	0-0.2 Poor	0.2-0.4 Fair	0.4-0.6 Good	0.6-0.8 Very good	>0.8 Excellent

3. Results & Discussion

3.1 Fabric Structural Properties

The each sample structures were developed by using two different yarn counts and loop length were selected accordingly. The developed fabrics were evaluated according to the standards and the fabric properties have been mentioned as below –

Sample	Yarn Count (Nm)	Wales/ cm	Course/ cm	Loop length (Cm)	Tight ness Factor	Areal density (gsm)	Thickness (mm)
SJ-Plain	2/100^s	14.3	20.7	0.28	15.98	128	0.70
	2/120^s	15.3	21.2	0.26	15.71	112	0.71
SJ-Pique	2/100^s	14.2	24.19	0.31	14.43	165	0.72
	2/120^s	14.0	25.62	0.29	14.08	149	0.73
DJ-Rib	2/120^s	9.4	19.5	0.34	12.01	204	0.92
	2/140^s	9.0	20.2	0.32	11.82	195	0.92
DJ-Interlock	2/120^s	13.4	24.0	0.32	12.76	225	0.98
	2/140^s	13.9	25.4	0.30	12.60	202	0.96

Table 3 Fabric Structural properties

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By altering the loop length course per unit length is changed because of alteration in the loop height. The areal and Course density of the fabric of pique is higher due to tuck stitches, which provides more widthwise extensibility. Yarn count plays vital role in adjusting weight of the fabric.

3.2 Fabric Physical Properties

The physical properties of the fabrics were evaluated according to the ASTM standards.

Sample	Yarn Count (Nm)	Bursting Strength (lb/sq.in)	Air Permeability ($cm^3/cm^2/S$)	Pilling resistance
SJ-Plain	2/100^s	63	340.12	4
	2/120^s	67	327.04	4
SJ-Pique	2/100^s	78	366.55	4
	2/120^s	82	354.32	4
DJ-Rib	2/120^s	81	278.2	4
	2/140^s	84	270.5	4
DJ-Interlock	2/120^s	80	230.6	4
	2/140^s	86	224.6	4

Table 4 Fabric Physical properties

Table 4 shows the physical properties of Eri silk knitted fabric. The Bursting strength of fabrics made from finer yarn is marginally higher because of increased twist level. The Pilling Resistance of Eri Silk knitted fabrics are better when compared cotton fabric and there is no difference between structures and yarn count. The air permeability of pique fabric is increased due to porosity of structures.

3.3 Effect of Repeated Washing on Area Shrinkage of Eri Knitted Fabrics

The length and width changes (expressed as percentage of area shrinkage) for each of the washing treatments are given in Table-6.

Fabric	Tightness factor	Wash I	Wash II	Wash III	Wash IV	Wash V
Single Jersey-Plain	15.98	-15.3	-12.2	1.6	-1.4	0.8
	15.71	-18.4	-12.8	-6.4	-3.4	0.6
Single Jersey-Pique	14.43	-26.5	-11.8	4.2	-5.4	-4.2
	14.08	-26.1	-11.4	7.2	-5.6	1.5
Double Jersey-1X1Rib	12.01	-20.8	-6.4	5.5	-5.7	-2.2
	11.82	-18.5	-5.6	4.5	-4.4	1.4
Double Jersey-Interlock	12.76	-16.3	-5.1	4.8	-5.8	1.2
	12.60	-15.4	-7.8	-5.7	5.2	-3.3

It is observed that the area shrinkage increases progressively, until they attain a stable state, due to repeated wash treatments. As a generalized trend, the fabrics with high tightness factor are able to quickly achieve structurally jammed condition and the area shrinkage value is negligible in further washes. Major part of area shrinkage occurs in the first few washes until they attain minimum energy state. The fabrics with lower Tightness Factor exhibit higher area shrinkage and they tend to shrink and expand alternatively in

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successive wash treatments. This is due to the reduced frictional forces at loop interlocking points. Also, the lower ratio of yarn diameter to loop length indicates more unoccupied area of loop which causes distortion during washing.

3.4 Moisture Transmission Properties

OMMC shows overall management performance of liquid moisture on fabric, and the higher value is the better liquid performance of fabric. AOTI is a value showing the amount of cumulative moisture difference between the two sides of fabric. Positive and high AOTI values shows that liquid sweat can be transferred from skin to the outer surface easily and quickly. On the other hand, negative and low AOTI values show that the liquid sweat can be transferred from the surface next to the skin to opposite surfaces and spread quickly with large wetted area.

Sample	WTt	WTb	ARt	ARb	MWRt	MWRb	SSt	SSb	AOTI (%)	OMMC
Single Jersey-Plain	4	4	3	4	4	4	3	3	4	4
Single Jersey-Pique	4	3	4	3	5	5	5	5	4	5
Double Jersey-1X1Rib	3	3	4	4	4	3	3	2	3	4
Double Jersey-Interlock	4	3	4	4	4	4	3	4	4	3

As understood from the above table 7, Eri silk knitted fabric strucres have better moisture management properties. OMMC value slightly decreased with the double jersey fabrics. It may be due to increased density and coverage of the fabric, the porosity is decreased. These knitted fabrics can dry quickly after sweating, make feel better in terms of the feeling of wetness after intense physical activities.

4. Conclusion

The studies revealed that the Eri spun yarn fabric has good Physical, Dimensional and comfort Properties. The working performance of fabrics was good at the time of cutting and sewing. It confirms the suitability of Eri silk knit materials for garmenting. The Knitted fabric produced from these yarns has good demand in international market because Eri spun silk fabric is produced by non violence and is stiffer, has luster, water permeable, stronger, durable, warmth is soft to wear, has good air permeability and is good in all season. Production of Eri Knit Wear and other fashion products out of Eri silk provides a better value addition which ultimately increases the price of eri cocoon and yarn; thereby improve the income of poor tribal producers. Eri Silk is skin friendly and it can be used for production of inner garments and thermal wear.

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