Optimum machinery, process and products for eri silk /wool blends

P. R. Kulkarni & R. S. Bahuguni

Wool Research Association, Thane

Abstract

Silk is known as the queen of all textile fibres because of its soothing luster and elegance. India produces all the four varieties of silks namely mulberry, eri, tussar and muga. Eri silk is the second largest variety of silk being produced in India and the production grew from 93 Metric Tons in 1950^{s} to over 1500 Metric Tons at present which is nearly 15 times. Eri silk which was earlier considered as wild silk, unlike other varieties, is non continuous filament silk Due to its compatible character with fine wool; it has been identified as the best component in blends with fine wool to impart soothing luster and strength to the product in homogenous blends, which is otherwise not possible with any other silk variety. Technically, it is quite advantageous to blend it with wool as this provides extra strength to the yarn and also soothing luster which adds to value addition to the blended products. Aesthetic values are far improved due to smooth luster, liveliness and improved thermal properties. Fine suitings, ladies wear; fine knit wears were developed using eri silk and wool blends.

Key words: Eri silk, wool, homogenous blend

1. Introduction

Silk is known as the queen of all textile fibres because of its soothing luster and elegance. India produces all the four varieties of silks namely mulberry, eri, tussar and muga. Eri silk is the second largest variety of silk being produced in India and the production grew from 93 MetricTons in 1950^{s} to over 1500 MetricTons at present which is nearly 15 times. Quantity wise it is next to mulberry silk and is approximately 7 – 8% of mulberry production. It is mostly reared in north eastern part of India like Assam, Meghalaya, and Tripura. Recently, because of efforts of Govt. of India, it is being reared in Madhya Pradesh, Andhra Pradesh, Karnataka and Gujarat. Eri silk is considered economically the third most important silk in the world after mulberry silk (Bombyx mori) and Chinese tussar silk and it has surpassed production of tussar silk, and muga silk. There is still much scope for increasing the eri silk production. Traditionally eri silk used to be reared in wild and hence known as wild silk which is a non-continuous silk by nature. Hence the tribals rearing it used the part of its production for producing coarse varieties of textile products and the remaining part was being

utilized as a food supplement (the pupae). Eri silk is always identified as Assam silk. Besides a few tribal inhabited districts of Bihar, Jharkhand, West Bengal and Orissa also practice this cottage industry as a subsidiary occupation. Recently, this sector drew the attention of Government of India and other Research institutions such as CSTRI and WRA have identified its potentiality to be the next silk variety after mulberry, which can be domesticated in a big way to produce silk spun yarn and blends and other value added items. Due to its compatible character with fine wool, it has been identified as the best component in blends with fine wool to impart soothing luster and strength to the product in homogenous blends, which is otherwise not possible with any other silk variety. By knowing the potentiality of these product mixes, through initial trials, Wool Research carried out a large scale research recently on these fibres (eri silk, wool), processing as well as machinery to be utilized for successful processing and producing value added products. During its course of work it has identified the problems in processing, the suitable machinery, optimum line of processing, scope for machinery modification, new inclusions, process parameters and possible blends which enhance productivity and also suitable machinery required for cottage, decentralized and commercial sectors for processing these eri silk/wool blends viable both technically and economically.

2. Concept of Eri Silk / Wool Blending

Wool and Eri silk, both are protein fibres. Wool is natural, fine and resilient with good elasticity and moderate strength. It is available with fineness in the range of 19 to 22 µm whereas an eri silk is a fibre available in cocoon form and is non continuous. It can be opened and cut to the required length suitable to mix it with wool. It has supple character with soothing luster with good strength better than wool. It is available in the range of 14 to 16 µm. Fortunately, it has similar thermal properties when compared with wool. Technically, it is quite advantageous to blend it with wool as this provides extra strength to the yarn and also soothing luster which adds to value addition to the blended products. Aesthetic values are far improved due to smooth luster, liveliness and improved thermal properties. As both being proteinous fibres, both are inherently flame retardant and slight percentage of application of FR chemicals will provide them additional flame retardancy. These advantages of improvement in aesthetic feel, flame retardancy and also indirect improvement in productivity in spinning and weaving of these blends gives an extra value addition to the products which also make them economically viable. The following tables

show the near compatible characteristics of eri silk / wool and comparison with other silk varieties.

Sr. No.	**Properties**	**Mulbery Silk**	**Muga Silk**	**Tussar Silk**	**Eri Silk**
1.	Average Single Fiber Strength (gms) (Tested on INSTRON Tensile strength machine specimen length 1.0 cm)	7.2	9.8	8.9	4.20
2	% Elongation at Break	11.3	15.3	14.5	12.4
3	Tenacity (gms/Denier)	6.5	3.7	1.70	2.58
4	Denier(Calculated on assuming Density of silk 1.33)	1.1	2.7	5.1	1.6

Sr. No.	**Property**	**Fibres**		
		Wool	**Eri Silk**	**Mulberry**
1.	Average Micron	(19 – 23)	(14 – 16)	(12 – 13)
2.	Single fibre Strength (gm)	3 – 4	4.2	7.2
3.	Elongation % at break	30-40%	12.4	11.3
4.	Tenacity gms/den	2 – 2.3	2.58	6.5
5.	Denier	2 – 3	1.6	1.1
6.	Average Fibre Length in mm (Sliver Top)	68 – 72	60 – 70	60 – 70

3. Technical Details

Eri silk is a protein fibre. The fineness range of this fibre is between 14 to 16 u. It is not a continuous filament and is to be spun into a yarn. The cocoon is open mouthed and when opened constitutes shorter filament and longer filaments the range of which may be 5 cm to 200 cm or more. It is supple, lustrous and has tendency to lap when tried to open and roll. It can be blended with cotton, wool and similar finer fibres. But economically and technically it is viable to blend it with wool. It has similar thermal properties like wool, length can be cut

to size to accommodate with wool. The eri cocoon contains sericin gum on the surface of the filament. It is to be degummed before processing. Presence of sericin will make it difficult to open and further processing. Delicate degumming is necessary as it should not spoil the structure of fibre continuity and it should help in better opening during cocoon opening process. Cocoon opening is to be such that the fibres in non-filament form are to be extracted without cutting and the pupae, even if present, is to be separated without any fibre loss and contamination. So the cocoon opener is to be such that a clean sheet of non-continuous filament fibres should be the outcome, after opening. Second stage of processing is, cutting to the required size i.e. to blend it with wool. Manual cutting always pose a problem as definite length cannot be cut. It cannot be accurate. This may lead to variation in fibre length after carding and combing and finally it results in non-accurate count and yarn imperfections and also the productivity will be low. Modified power operated twin blade/three blade cutter has been designed and fabricated to cut the designated fibre length. This will be accurate with high productivity. Manual errors have been totally eliminated. Desired length and accurate results of noil extraction will be obtained during further process. Manual cutting sometimes poses problem during carding and may lead to lapping of fibres which will deteriorate the quality of the delivered material. The next process after cutting the fibres to accurate length is parallelizing and individualizing fibres and to deliver the material in the form of uniform sliver. Trials conducted during the project on cotton flat card and worsted card with flexible card clothing, when processed on these cards, problem of lapping of silk fibres was observed even though changes in settings were made to suit processing, and also when cut eri silk was processed on mini card (20”) width with metallic wire covered. Lapping do occur on likerin and cylinder. Initially you can observe good quality silk web coming out but later quality deteriorates and loading of rollers increases on all the three types of cards. From these observations necessary modifications and changes in wire specifications, dia of rollers, settings were analyzed and changed/ modified design and fabricated card has been developed suitable for processing eri silk of required cut length.

Next process required for carded sliver is drawing. As cotton drawframe is technically not suitable, worsted gilling process was thought to be the right process. Low speed gilling upto 50 to 80 mts/min on models GN 4 and GN 6 was found suitable for eri silk processing. Comber model PB 30 with a maximum nip/min of 90 was utilized, as further series were found to deteriorate the effective fibre length. So no modifications and changes were made to these machineries and were included in the process line as it is, with their machine

specifications and range of speeds and settings. Eri silk and wool blending was found suitable in their top form. This results in technically viable blending with low percentage of wastage and also maintaining a thorough blend mix with exquisite quality in each blend.

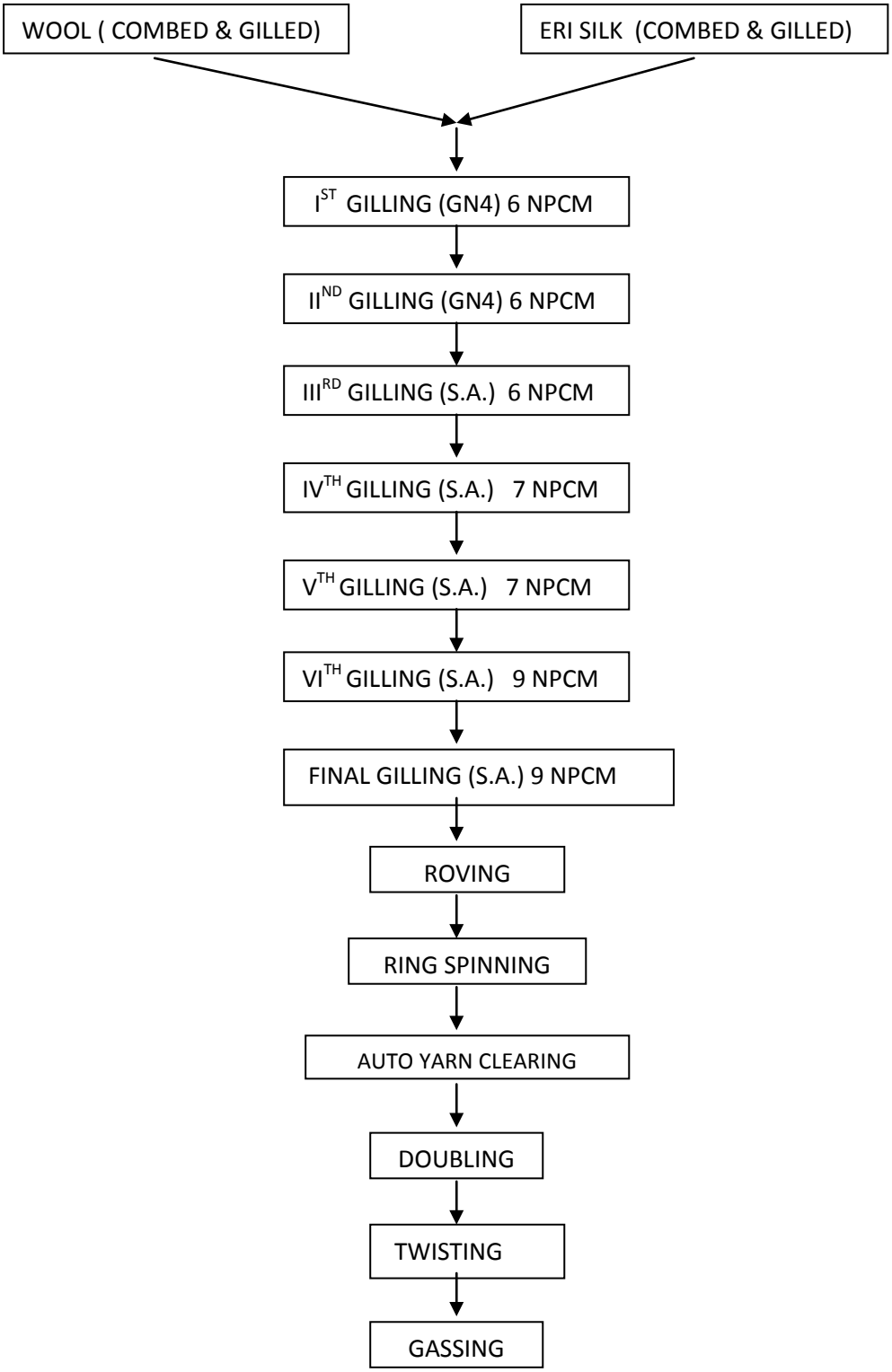
Further processes included were roving and spinning. Worsted roving with three over three drafting with apron drafting system was found suitable compared to silk roving and spinning with 5/5 slip drafting system .worsted spinning system with 3/3 slip drafting was found adequate to make quality yarn for decentralized sector. However, for cottage industries it is convenient to provide the cottage industry with combed and drawn sliver (finisher) of blends to enable them to spin either by hand spinning or else by two to six spindle charka with 3/3 drafting system. To spin yarn directly from sliver, a modified, hand operated, two spindles ring frame was designed for spinners of migratory nature.

4. Optimum Process Line / Machinery

Wool Research Association undertook large scale research and development work for developing precise machineries for processing individually eri silk and also eri silk/wool blends. Many trials were initiated to design/devise processes and processline at cottage level, decentralized level and for commercial industries. For this, trials were conducted on different spinning systems such as worsted, cotton and spun silk. Observations were made for suitability of machinery and processes for processing these blends and problems faced during these trials were noted. These trials gave lot of ideas about the material parameters processing conditions, modifications required in machineries and also quality parameters in the output material and quality parameters to be maintained for material inputs. These initial and large scale trials gave information about blend composition to be maintained for achieving required quality parameters in the yarn and the fabric. Optimum process line and machinery could be concluded after these fruitful initial trials. The optimum process line and machinery involved for processing these eri silk /wool blends have been depicted in the process flow charts given as below:

BLEND OF ERI SILK/WOOL PROCESS LINE

(PROCESS ADOPTED)



5. Description of the Processes Involved

Form of availability of raw material of eri silk and fine wool differ, and also basic fiber properties vary, hence they need to undergo different processes till they are suitable for good blending. The eri silk is always available in cocoon form and open mouthed and the insect inside the cocoon is always allowed to pierce the cocoon to go out. And by nature, it is non continuous and there is no loss as such if the insect is not killed ,except some discoloration of the cocoon due to urination while coming out of the cocoon . These cocoons contain sericin gum which is to be removed for further smooth processing. So the first process is degumming further followed by other processes till top conversion.

Brief Description of the processes involved for Eri-silk.

Degumming: Eri silk contains 10-15 % of sericin which is to be removed either by boiling with soap water or through scouring in vats followed by hydro extraction. This process reduces the sericin content to 2-3% which is optimum for further opening and carding. This process also opens the cocoon to a fluffy form.

Cocoon opening: The degummed cocoons are opened in cocoon opener to convert the cocoon fibre in the lap form. This will be helpful for further cutting the eri silk fibres to the required length suitable for blending with wool in the form of silk top. The cocoon opener needs to be gentle in action for better yield of silk in further processes. Presently the cocoon opener being used for mulberry silk waste is also being put to use for eri silk. Modified design is required to be introduced for improving yield and reduce waste percentage.

Fibre Cutting: The process is for cutting the eri silk lap, for required length, for example 80 mm/100 mm. Manual cutting is inaccurate. Hence twin blade cutter, modified for eri silk cutting will be suitable.

Carding: The process is for parallelizing and individualizing the eri silk fibres. Uniform feeding of cut eri silk fibre is essential for maintaining quality of the output. It is also essential to priorly open and free the cut eri silk from remnants of the insects so that Nep % will be low in the output.

Gilling ; Series of gilling and drawing operation render the carded sliver fibres parallel and uniform, Normally slow speed gilling operation with 80-100 meter/min speed with increasing needles/cm in every operation will be beneficial to achieve good quality output. Normally 3-4 gilling/drawing operations are necessary for quality gilled sliver before combing.

Combing: This operation removes shorts fibres and neps present in the gilled uncombed eri silk sliver. This operation retains only long range of fibres suitable and compatible to blend it with fine wool top fibres. Normally the waste percentage will be in the order of 40 – 42%. But if better preparatory machines for cocoon opening and carding are used then the waste percentage can be reduced to 20-25%.

Post comb gilling: The combed eri silk sliver is processed on gilling/drawing machines 4-5 times to get the finished eri silk top of required weight suitable for blending with wool top.

Brief description of the processes involved for fine wool:

Raw wool also has to undergo cleaning, opening before getting converted to wool top form of required weight suitable to blend it with eri silk top. The description of the processes is as below:

Scouring: Scouring is a process of removing wool grease which is 20-25%. The scouring operation removes the grease content and brings it down to 5%. Other impurities such as dust, suint are also removed in this process rendering wool free from all impurities except vegetable matter. The wool is then dried, oiled and sent for carding operations.

Carding: This operation removes vegetable matter and opens & individualizes the wool fibres and converts the wool into sliver form known as carded wool top.

Gilling: This operation gills and draws the carded sliver and improves its parallization and uniformity suitable for combing.

Combing: This process removes short fibres to the tune of 8-10% by retaining range of long fibres needed for fine spinning of eri silk/wool blends.

Post comb gill boxes: These processes after several gill/draw operation will prepare the uniform parallel sliver row known as combed wool top of required weight/meter.

After these operations the **Eri silk top and Wool top** were blended in top form through the following processes.

Blending Gilling: Normally 5 -6 operations are necessary with increasing NPCM after every operation for thorough blending of both these fibres. The number of slivers of each depends on the composition required in the blend and weight /meter of individual slivers.

Finisher Gilling: This is the final gilling operation where in the blend gilled sliver is drawn further three times to achieve fine weight of sliver (5-6 grams) suitable for further process i.e.roving.

Roving: In roving the drawn and reduced sliver (5-6 gms/mtr.) will be further drawn on drafting system to still finer state known as Roving. This roving fineness is set as per the fineness of the yarn required to be spun on Ring Frame.

Ring Frame: In this process, the roving is further drawn 25 – 30 times (which depends on final fineness of yarn to be spun) and required twist is inserted in the yarn for finally obtaining the required fine yarn in the form of condensed package.

Autoclave: It is a yarn conditioning process to set the twist in the ring spun yarn. By this the yarn gets balanced and will be free from snarls.

Auto Yarn Clearing: In this process, the yarn will be cleared of thin and thick places. Electronic clearing devices on auto yarn clearing m/c sense the irregularities in the yarn & will remove them by cutting and joining the ends by further knotting /splicing techniques.

Parallel Winding: This process prepares double yarn package in cheese form.

T.F.O. Twisting & Gassing: In this process the doubled yarn obtained from parallel winding process gets optimum twist to be together and the twisted yarn will be wound in the form of conical package or in the form of cheese. Gassing removes hairiness in the yarn and renders it a soothing luster on the surface.

6. Optimum Process Parameters Based on the experience of initial trials, optimum speeds and draft were selected for every process while processing Eri silk/wool blends. Table I below gives details of optimum machine parameter adopted.

Table I

Machine Parameters For Wool/Silk Blends (60s Nm)				
S.N.	**Process**	**Speed**	**Draft**	**Drafting System**
1	Cocoon Opener	Cylinder r.p.m 200-250	-ve	Collecting opened material on cylinder
2	Carding	Cylinder 80 – 100	80-100	Draft between feed rollers to licker in to cylinder & Doffer
3	Gilling	50-60 mtrs per min	5-8	Back rollers to delivery rollers
4	Combing	90 nips/min	30 - 35	In turn of noil removal
5	Roving	10 mtrs/min	9 -10	Apron 3/3 drafting system (worsted type)
6	Spinning	10 mtrs/min S.S. 5000 RPM	20 - 25	5/5 Slip draft system
7	Auto Yarn Clearing	600 mtrs/min	-	-
8	Twisting	S.S -4000 – 5000 RPM, 10 mtrs/min	- -	- -
9	Gassing	400 - 500 mtr/min	-	-

6. Product Development

Blending of eri silk / wool involved homogenous blending of pure eri silk with pure merino wool of 19 microns and 21 microns respectively. Three different compositions of these fibres were planned to spin counts ranging from 28^s Nm to 90^s Nm. Specially fine 19 micron wool was used in blending for spinning counts above 60^s Nm. 21 micron wool i.e. medium quality merino wool was utilized to spin yarns of count below 60^s Nm. The range of yarn counts spun with the respective product range has been depicted in Table II.

TABLE II

Sr. No.	Count Nm	Product	Blend Composition
1	2/28	Knitting (knitwear)	50 / 50 (silk /wool)
2	2/28	Weaving (Tweeds)	50 / 50 (silk /wool)
3	2/40	Weaving (Ladies wear)	25 / 75 (silk /wool)
4	2/60	Suiting	25 / 75 (silk /wool)
5	2/60	Suiting	50 / 50 (silk /wool)
6	2/90	Suiting	40 / 60 (silk /wool)
7	2/90	Suiting	25 / 75 (silk /wool)
8	2/90	Suiting	50/50 (silk/wool)
9	2/90	Scarf	50 / 50 (silk /wool)
10	2/60	Pure Silk	100% (silk)

Table III depicts the range of eri silk / wool blended yarns developed and their characteristics

Table III

Sr.No.	C.No.	Count (Metric)	Strength (Gm)	Elongation %	U%	Thin- 50% Per Km.	Thick 50% Per Km.	Neps +200% Per Km.	Set Count	Composition
Single Yarns										
1	A-1	1/55	218.4	15.3	19.61	565	420	1145	1/60	50/50
2	B-1	1/106.6	145.6	11.8	21.65	1930	1130	1360	120^{s}	PURE SILK
3	C -1	1/54.3	331.0	16.3	14.92	80	440	1550	60^{s}	PURE SILK
4	D -1	1/110.2	134.4	11.3	20.68	1990	1025	1545	120^{s}	PURE SILK
5	E -1	1/58.7	125.4	9.8	19.36	980	440	835	1/60	25/75
6	F -1	1/36.8	266.4	13.6	20.62	235	235	245	1/40	25/75
7	G -1	1/32.9	354.4	19	12.85	35	335	485	1/32	50/50
8	H - 1	1/56.8	130.4	10.3	20.72	1290	640	530	1/60	25/75
9	I - 1	1/91.2	98.4	9.6	21.45	1525	765	680	1/90	25/75
10	J -1	1/88.4	110.4	10.3	19.69	1450	1040	1285	1/90	40/60
11	K -1	1/87.5	114.4	12.3	22.4	1735	995	1095	1/90	50/50
Double Yarns										
1	A	2/125.2	312.4	15.3	14.25	230	170	80	2/120	PURE SILK
2	B	2/29.03	702.4	16.3	9.01	0	10	20	2/28	50/50
3	C	2/94.9	266.4	13.6	13.22	65	80	85	2/90	40/60
4	D	2/97.1	290.4	16	12.66	85	60	45	2/90	50/50
5	E	2/37.9	402	15	10.21	0	30	50	2/40	25/75
6	F	2/59.6	542	12	11.4	5	10	5	2/60	50/50
7	G	2/95.4	302.4	16.3	9.37	0	20	55	2/90	50/50
8	H	2/60.8	342.4	13	11.59	40	25	10	2/60	25/75
9	I	2/35.8	392	14	10.19	0	0	5	2/32	25/75
10	J	2/92.5	212	18.3	10.98	0	15	25	2/90	25/75
11	K	2/62.7	242.4	13	14.42	100	75	75	2/60	PURE SILK

Innovative fabrics such as suiting, knit wears, tweeds and scarves were developed using the above yarns. Table IV and V give the construction parameters with respect to different compositions of warp and weft made of eri silk / wool blended yarns. These fabrics were developed both on hand loom and shuttle less looms such as Nupignone, thus proving their versatility and utility ranging from hand loom to shuttle less looms.

Table IV

Sr.No.	Sample Code	Warp Nm	Weft Nm	Composition		Reed count	Reed space	Loom Pick	Weave
				Warp (%) S/W	Weft (%) S/W				
1	A	2/60 ^{S}	2/60 ^{S}	50/50	50/50	26/2	20”	52	Plain
2	B	2/90 ^{S}	2/90 ^{S}	25/75	25/75	31/2	20”	60	Twill
3	C	2/60 ^{S}	2/60 ^{S}	25/75	25/75	26/2	20”	52	Plain
4	D	2/60 ^{S}	2/60 ^{S}	100%	100%	26/2	20”	52	Plain/twill
5	A1	2/60 ^{S}	2/60 ^{S}	50 / 50	50 / 50	52 ^{S}	44”	44	--
6	B1	2/60 ^{S}	2/60 ^{S}	50 / 50	50 / 50	52 ^{S}	44”	44	--
7	C1	2/60 ^{S}	2/60 ^{S}	50 / 50	50 / 50	52 ^{S}	44”	44	--
8	D1	2/60 ^{S}	2/60 ^{S}	50 / 50	50 / 50	52 ^{S}	44”	44	--
9	E1	2/60 ^{S}	2/60 ^{S}	50 / 50	50 / 50	52 ^{S}	44”	40	--

Table IV depicts the range of eri silk / wool blended fabrics woven on hand looms. The structural design chosen were plain and twill structure with gms/sq. mt. ranging from 150 to 250.

Table No V below depicts the eri silk / wool blended fabrics woven on Nupignone shuttle less looms and plain structural pattern was chosen for better comparison of the fabrics for various fabric properties with gms/ sq. mt. between 160 to 170 for fabrics coded as Fz1 to Fz 9. The fabric coded as DYG and DYF were designed to have low gms/ sq. mt of 120 to 150 for utilizing them for men’s safari and light weighted suitings.

Table V

Sr.No.	Sample Code	Warp Nm	Weft Nm	Composition		Reed count	Reed space	Loom Pick	Grey pick	Weave
				Warp (%) S/W	Weft (%) S/W					
1	Fz1	2/60	2/60	50/50	50/50	26/2	67	52	54	Plain
2	Fz2	2/60	2/60	100/0	50/50	26/2	67”	52	54	Plain
3	Fz3	2/60	2/60	25/75	50/50	26/2	67”	52	54	Plain
4	Fz4	2/60	2/60	50/50	100/0	26/2	67”	52	54	Plain
5	Fz5	2/60	2/60	100/0	100/0	26/2	67”	52	54	Plain
6	Fz6	2/60	2/60	25/75	100/0	26/2	67”	52	54	Plain
7	Fz7	2/60	2/60	50 / 50	25/75	26/2	67”	52	54	Plain
8	Fz8	2/60	2/60	100/0	25/75	26/2	67”	52	54	Plain
9	Fz9	2/60	2/60	25/75	25/75	26/2	67”	52	54	Plain
Details Of Dyed Samples										
10	DYG	2/90	2/90	50/50	40/60	36/2	67”	50	52	Plain
11	DYF	2/60	2/60	50/50	40/60	36/2	67”	50	52	Plain

Performance Characteristics

TABLE VI

FABRIC TEST RESULTS										
SR NO	TEST	SAMPLES								
		Fz1	Fz2	Fz3	Fz4	Fz5	Fz6	Fz7	Fz8	Fz9
1	BREAKING STRENGTH (KG)									
	Warp	53.2	68.4	41.4	54.8	67.8	41.1	51.2	65.6	38.6
	Weft	45.4	44.4	42.4	57.8	59.6	59.1	37.4	37.1	37.2
2	ABRASION RESISTANCE (No end print reached upto20,000 rubs)									
	% Loss in weight (gms)	2.2	1.8	2.8	2.1	1.6	1.8	2.6	1.4	2.8
3	THERMAL INSULATION VALUE									
	TOG	0.19	0.37	0.29	0.32	0.32	0.41	0.64	0.25	0.14
	CLO	0.29	0.57	0.45	0.49	0.49	0.64	0.99	0.38	0.22
4	PILLING RESISTANCE	4	4	4	3 - 4	4	3 - 4	4	4	4
5	COLOUR FASTNESS (XENON)	4	4	4	4	4	4	4	4	4
6	WASHING FASTNESS (ISO-2)									
	a. CHANGE IN SHADE	4	4	4	4	4	4	4	4	4
	b. STAINING ON COTTON	5	5	5	5	5	5	5	5	5
	c. STAINING ON SILK	5	5	5	5	5	5	5	5	5

7. Discussion

Spun Silk industries whether cottage, decentralized or commercial utilize silk wastes generated in silk industries which utilize continuous silk filaments such as varieties of mulberry (bivotaine, mullivoltaine) muga and tussar. In these industries waste is generated during degumming, reeling, throwing, winding, warping, weaving and finishing operations. These silk wastes are segregated as damaged cocoon, unwound cocoon and filamental soft waste and hard waste. Eri silk though being the second largest variety produced in India, confined only to north eastern states. It was primarily considered as a wild silk and only tribal people majorly used eri pupae as food supplement and minor portion of it was allowed to develop into cocoon. The open mouthed eri cocoon used to be hand opened after extracting moth by cutting the cocoon or else moth allowed to fly out on its own. Such hand extracted fibre used to be handspun to coarser and irregular counts to be used as yarn for handlooms on which coarse fabrics such as shawls and blankets used to be woven for tribal regions.

If eri silk would have been a continuous silk filament yarn, then it could have entered the main stream of silk processing similar to mulberry, muga and tussar. But unfortunately by nature itself it is spun non-continuously by the eri silk worm. So much attention was not given to its rearing or to its systematic processing and since past it remained a traditional fibre and restricted itself to north eastern states where it is still being spun to its coarse counts for blankets and shawl making, commercial usage of eri silk has just started, may be partly due to shortage of mulberry silk waste, so observation made in the recent past have revealed that processing of eri (preparatory & post) is similar to waste silk processing. So it is observed that, this kind of practice is devaluation of virgin eri cocoons, though these cocoon may contain short and long filaments, if proper methods of degumming and opening of cocoon on modified /new machines are carried out, it can yield a good quality opened fibres which can be cut in the required size for blending them with natural fibres like wool, cotton and even synthetic fibres to spin a virgin yarn for export oriented products.

In the recent past because of efforts of Central.Silk.Board, eri silk rearing got a boost and domestic rearing of eri silk took its beginning. Commercial spun silk industries began to use eri silk for spinning spun silk to make fine counts and convert it into a more value added product, otherwise confined to handspun irregular non-value added products. Regular (often old worsted machinery) machineries which were being utilized for processing silk waste of

filament of mulberry, muga and tussar varieties were put to use for processing eri silk also. Recognition of eri silk as a virgin fibre and better understanding of fibre properties and ways to involve good processing machineries, processes were never attempted till recent past. Its compatibility with fibres such as wool and spinning techniques, processing machineries compatible for both fibres were never experimented were not tried, which would have paved the way out for highly export oriented value added products. It is at this stage, Wool Research Association after conducting successful initial studies and trials involving both the fibres, stepped into design and develop compatible machine for processing individually eri silk and eri silk wool blends, which have credibility of maintaining virginity, quality, yield and productivity of the processes and produce innovative quality products.

Achievements

- Dubbed as wild silk before, the eri silk was in use by tribal people for making coarse products. Now due to the recent research done by WRA and CSTRI, this kind of wild silk has shown its suitability for fine spinning and also possibility for blending with fine wool for fine spun blended yarns and fabrics. The findings have boosted its chances of domesticating the rearing in a big way.

- High value added products like suitings, ladies dress materials, tweeds, shawls and knit wears could be designed with these eri silk / wool blended yarns. Thus a new avenue for eri silk has been created for high value added products.

- Optimum methods for degumming and cocoon opening, cutting, blending and opening for eri silk have been evolved, thus resulting in achievement of high yield levels and good blending of eri silk with wool.

- Process parameters and material parameters for fine spinning of these blends were evolved.

- Fine blended yarns with varying compositions of wool/ eri silk in the range of 50/50, 60/40 & 75/25, were found to boost the productivity in both spinning and weaving when compared to 100% woolen yarn of same fineness.

- Fine product like fine fabrics and knit wears were made possible, which have exhibited better aesthetic and comfort values.

- Effective ways of blending techniques for eri silk / wool have been evolved and the stage of blending these two fibres was perfected through research and trials.

- Performance characteristics and tailorability properties of these fabrics are excellent and they have achieved good fastness properties for both natural dyes and synthetic dyes. Now it has been made possible for manufacturing fine fashion garments.

- Major achievements of this work, as far as machinery development were, Designing and fabricating machineries such as fibre cutter, carding, computerized roving frame and computerized ring frame for spinning eri silk /wool blends. These machines have been designed to make them versatile enough to handle blends of eri silk / wool to handle different blend compositions. Thus a systematic line of machineries involving newly designed machines and compatible old machinery could be evolved for fine spinning of these blends beyond 90s Nm. Preparatory machinery like cocoon opener and 2 spindle spinning machinery for cottage industries were designed for cottage industry. These machinery developments have improved the production and spinning capability of these blends.

- Yield percentage of eri silk when processed on newly designed preparatory machines has improved by 10%.

- Now it is possible for hand spinners to get ready made and compatible carded eri silk uniform sliver and also eri silk / wool blended sliver for hand spinning even yarn.

- The quality of out put in the form of sliver has improved due to which there can be proper blending of eri silk with wool.

8. Conclusion

Eri silk is quite compatible with wool of finer quality (merino) and can be processed on worsted machinery in the top form. Much research is still to be done on preliminary processing such as degumming and cocoon opening, cutting and carding to increase yield and to make it compatible with wool for spinning it to a finer level and to give maximum strength to the yarn in blends with wool for finer counts above 90^s Nm. Compatible process line to blend eri silk / wool has been developed and classic blended yarns suitable for weaving fine and medium suiting fabrics and ladies wear have been developed. Blended yarns for medium and fine knit wear which can work on finer gauges of knitting machine working at high

speeds were made possible. Through this research work now it is clear that there is wide scope for eri silk usage in products meant for high end users and exports.

Design and development of the machineries under this project were aimed at setting up a perfect process line based on scientific and technically feasible methods for processing virgin eri silk and its blends with wool. Efforts were made to develop machineries for cottage industries like Twin Spindle hand driven sliver to yarn spinning, where a combed blended sliver silk/wool from a decentralized sector can be supplied to cottage industry in the required gm/mt, so that even fine yarn can be spun on this twin spindle which can be extended to even six spindle, which is qualitatively and quantitatively acceptable for all the concerned. The well designed process line includes eri silk cocoon opener, twin bladed power operated fibre cutter, eri silk carding machine, gilling, combing, and computer controlled roving, spinning machines. The machines will be quite versatile enough to handle varying composition of blended eri silk / wool material and can spin a quality yarn upto 80^s Nm.