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Short Communication

Comparative weaving performance assessment of tasar yarns produced by different cocoons softening process

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This study evaluates the comparative performance of tasar filament yarns during weaving preparatory and weaving processes following standard handloom procedures. Twisted and untwisted 60 denier (nominal) yarns are used as warp and weft, respectively. The yarns are produced using three cooking processes: (i) sodium carbonate with soap, (ii) hydrogen peroxide with soap, and (iii) sodium carbonate with sodium bi-carbonate. A significant reduction of winding breaks is observed for both yarns produced by sodium carbonate in combination with sodium bi-carbonate as well as hydrogen peroxide and soap cooking process, compared to the sodium carbonate and soap technique. Weaving trials reveal higher warp and weft breaks in yarns from the sodium carbonate and soap process, attributed to fibroin degradation due to high pH. Fabric woven from these yarns also shows a greater number of defects per metre. Thus, the sodium carbonate and sodium bi-carbonate or hydrogen peroxide and soap cocoons cooking technique prove more effective for producing yarns suitable for tasar fabric weaving.

Keywords: Degumming, Pirn, Tasar fabric, Weaving, Weft

The majority of tasar silk fabrics are produced in India using handlooms. About 15 % of total handloom production is engaged in silk weaving, and renowned silk sarees like Kanjeevaram, Ikkat, Baluchari, Benarasi, etc., are produced from mulberry yarns, besides Matka saree from tasar silk[1]. In earlier days, untwisted tasar yarns produced by thigh (natwa) reeling were used for tasar silk weaving. Rice starch sizing was applied to the warp yarns to help them withstand tension during fabric formation, while untwisted yarns were used as weft[2,3]. Advancement of tasar cocoon cooking/softening processes facilitates different techniques like enzymatic using Biopril 50 and Anilozyme P, peroxide using hydrogen peroxide along with soap as well as non-peroxide treatment by sodium carbonate along with sodium bi-carbonate[4-9]. Among these, hydrogen peroxide and carbonate techniques become popular in tasar sectors due to easy procedures and lower cooking costs. However, for warp usage, twisting of tasar yarns is essential to avoid filamentation and entanglement and to withstand tension during the shedding and picking motions of weaving. Due to the higher tenacity of temperate (oak) tasar yarn and retention of residual sericin in filament because of the wet reeling yarn production technique, the same can be used as warp without twisting. In the tasar sector, 40 denier Korean tasar yarns are very popular for warp produced from temperate tasar. But for weft, 60 denier untwisted yarns produced from tropical tasar cocoons are used[2,3,7]. Studies reported about single cocoon reeling parameters (filament length, non-broken filament length& denier), reeling performance (reelability, raw silk recovery & yield/1000 cocoons), fibre and yarn quality (tenacity & breaking elongation) for tropical and temperate tasar[5-7,9]. Also, standard procedures and norms have been established for tasar yarns as guidelines for tasar reeling sectors[10]. During reeling of tropical tasar cocoons, excessive breaks occur because of lower non-broken filament length, resulting in the presence of more missing ends as well as knots in yarns[11,12]. Untwisted tasar yarns reeled by using Motorized Tasar Reeling Charkha (MTRC) have superior quality as evaluated by standard procedures[10] and can be used as weft[13].

Studies reveal significant deformation in the Hookean region along with the strain hardening of raw un-degummed organzine and degummed organzine mulberry warp silk yarns during weaving as evaluated by cyclic loading in the tensile testing instrument[14]. Performance of 20/22 denier mulberry silk yarns can be improved during winding, doubling and twisting by following the mrudula oil soaking technique, which facilitates the plasticization of sericin. So, the fibroin becomes pliable with improved cohesive strength, which results in better preparatory and weaving performance[15]. Effective yarn engineering, along with a selection of quality cotton fibres, yarns

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can be effectively utilized in the high-speed shuttle as well as shuttle less looms[16]. For cotton yarns, 20 g/tex and higher RKM value with a co-efficient of variance below 10 %, breaking elongation of 5 % and more, total imperfections below 300/Km and hairiness index value below 5 are required for utilization in high-speed shuttle less looms like a projectile, air- jet and rapier[17].

Yarn hairiness, volume, linear density, fibre type and twist level significantly influence on twist loss and weft yarn velocity during the weaving of cotton and polyester/cotton yarns in an air jet loom. High hairiness and thin yarns exhibited higher velocity but greater twist losses, whereas highly twisted yarns demonstrated lower velocity and higher twist loss. Polyester yarns showed lower velocity and more twist loss than cotton yarns[18]. Yarn type, loom speed and air pressure delivered by the relay nozzle in the air jet loom substantially influence on the air permeability of fabrics. The air permeability of fabric for rotor spun yarn is greater than that of ring spun yarn used as weft. With the enhancement of loom speed and relay nozzle air pressure reduction, the air permeability of fabric increases and vice versa[19]. A similar study revealed that fabric produced in an air jet loom using ring spun yarn has a smoother surface and better drape characteristics than rotor spun yarn. With the increase in warp and weft tension, the surface roughness of the fabric increased, and the fabric drape decreased. The fabric drape decreased as weft density increased, and the fabric surface roughness increased as weft density decreased[20]. Polyester/cotton blend ratio, loom speed and air pressure significantly affect the twist level and strength of yarn during weaving in an air jet loom. Relay nozzle air pressure is directly proportional to twist loss and weft yarn strength loss[21]. A deep learning model based on artificial intelligence was established to recognise handloom and power loom fabrics better and distinguish them during assessment. This model has better accuracy and adaptability to the specific classification problem. The parameters considered were fabric feel, weft uniformity, occasional lumps, selvedge markings and type of yarn[22].

So, from the literature review, it was found that winding and weaving performance assessments were carried out for mulberry silk yarns. Also, studies have reported on these aspects of cotton, polyester, and polyester/cotton yarns, along with the yarn quality requirements for high-speed shuttle less looms. The application of artificial intelligence to distinguish handloom and power loom fabrics during assessment was also attempted. For tasar yarns, no study has been reported regarding the performance of reeled yarns at the preparatory and weaving stage produced from softened cocoons through different existing cooking processes except single cocoon characteristics, reeling performance and yarn quality. As most tasar fabrics are produced using handlooms, this study evaluates tasar reeled yarns by following the standard handloom preparatory and weaving procedures.

Experimental

Twisted tasar filament yarns and untwisted tasar filament yarns, each 500 g of 60 denier (nominal), were used as warp and weft, respectively, for the weaving of fabrics. The yarns were produced by following three different cocoons cooking processes inclusive of sodium carbonate with neutral soap[3,4], hydrogen peroxide with neutral soap[7] and sodium carbonate with sodium bi-carbonate[8,9].

Assessment of Yarn Denier and Tensile Characteristics

Yarn fineness (denier) was measured by following standard procedure[23]. For this purpose, a 112.50 m length of yarn was wound onto a wrap reel (Epprouvette), and subsequently, its weight was measured using a precision electronic balance with a sensitivity level of 1 mg. 50 observations were taken for each yarn sample. The tensile characteristics of yarn were assessed by using a Universal Tensile Testing Machine (UTTM) (Zwick, Switzerland, Model Instron 4482) following standard procedure[24]. For tensile characteristics assessment, a 50 cm length was mounted between the upper and lower jaw, maintaining a crosshead speed of 500 mm/min. 50 observations were taken out for each yarn sample, and the statistical parameters of tensile characteristics (breaking load, tenacity and elongation) were taken from the computer interface of UTTM.

Preparation of Bobbins for Warp Beam and Weft (pirn)

Bobbins for both warp beam and weft (pirn) were prepared using twisted and untwisted tasar yarns, respectively by manual winding process followed in handloom preparatory[2,3]. Breaks were noted during winding from the lea/hank of both twisted and untwisted tasar yarns of 1.5 m circumference.

Preparation of Warp Beams

Warp beams were prepared from double-flanged wooden bobbins (78 mm length with 4 mm flange and

52 mm outer diameter) placed on the wooden warping creel followed by winding on wooden drum by manual procedure[2,3]. A total 60 bobbins were placed on a wooden warping creel, and 48 sections were done on the wooden warping drum. So, the total number of ends is 2880.

Drawing and Denting were carried out manually following the usual practice of handloom preparatory[2,3]. For denting, 60 count reed was used.

Assessment of Weaving Performance

Warp and weft breaks were noted for each type of yarn during weaving. Total 5 m plain weave fabric was woven using warp and weft of each yarn sample. The breaks per unit length (meter) was estimated by the ratio of total breaks and fabric length.

The ends and picks per centimeter in the fabric were measured by following standard procedure[25] using counting (pick) glass.

After fabric formation, the number of defects present in the fabric was counted by visual assessment, like missing yarns (warp & weft), slubs, hairs, etc. The number of defects per unit length (meter) was estimated by dividing the total defects present in the fabric by the length of the fabric.

The yarn and fabric samples were kept under standard atmosphere conditions, i.e., 65±2% relative humidity and 27±2°C temperature for 24 h[26], subjected to assessment of yarn denier and tensile characteristics as well as thread density in fabric.

The experimental data were analyzed for parameters viz. yarn denier, tensile characteristics, thread density in fabric, warp and weft beaks and fabric defects using MS Excel software.

Results and Discussion

Yarn Denier and Tensile Characteristics

The fineness (denier) and tensile characteristics of tasar yarns are depicted in Table 1 and Table 2, respectively, evaluated following standard procedures[23,24], which were produced following normal practices[3,7-9].

It is found that there is no difference in denier of tasar yarns produced using three different cooking processes followed, and there is no difference between twisted and untwisted varieties (Table 1). Marginal fineness (denier) of twisted tasar yarns is due to contraction of length by the insertion of twist. Table 2 suggests that the tenacity is significantly

Table 1 — Fineness (denier) of tasar filament yarns

Parameter	Cooking/softening process					
	Sodium carbonate & soap		Hydrogen peroxide & soap		Sodium carbonate & sodium bi-carbonate	
Type of yarn	Twisted	Untwisted	Twisted	Untwisted	Twisted	Untwisted
Average	70.10	67.50	71.50	59.80	70.50	66.20
Standard deviation (S.D.)	8.75	9.75	7.80	8.60	9.85	10.10
Standard error (S.E.)	1.24	1.38	1.10	1.22	1.39	1.45
Confidence interval (CI)*	2.43	2.70	2.16	2.39	2.72	2.80

No of observations: 50; length of yarn: 112.50 m; CI at 5% statistical level

Table 2 — Tensile characteristics of tasar filament yarns

Parameter	Cooking/softening process					
	Sodium carbonate & soap		Hydrogen peroxide & soap		Sodium carbonate & sodium bi-carbonate	
Type of yarn	Twisted	Untwisted	Twisted	Untwisted	Twisted	Untwisted
Tenacity						
Average (g/d)	1.75	1.30	2.30	2.10	2.45	2.35
Standard deviation (S.D.)	0.70	1.10	0.80	0.75	0.65	0.70
Standard error (S.E.)	0.10	0.16	0.11	0.11	0.09	0.10
Confidence interval (CI)	0.20	0.31	0.22	0.22	0.18	0.20
Breaking elongation						
Average (%)	24.30	25.10	30.40	28.50	34.20	35.00
Standard deviation (S.D.)	11.50	12.60	9.50	10.60	11.50	10.30
Standard error (S.E.)	1.63	1.78	1.34	1.50	1.63	1.46
Confidence interval (CI)	3.20	3.50	2.63	2.94	3.20	2.86

No of observations: 50; CI at 5% statistical level lower for conventional sodium carbonate along with soap cooking/softening process, whereas it remains at par for both hydrogen peroxide and soap as well as sodium carbonate and sodium bi-carbonate techniques. The deterioration of yarn tenacity for the conventional sodium carbonate softening process may be due to the higher pH of the solution, which affects the polypeptide bonds of silk fibroin[9,27].

Yarn Density

The yarn density (ends/cm and picks/cm) for the three fabrics produced is depicted in Table 3.

It is observed that there is no difference in thread density (warp and weft per cm) in tasar fabrics produced from yarns of three different cooking/softening techniques.

Table 3 — Yarn density in fabric

Parameter	Tasar cocoons cooking/softening process		
	Sodium carbonate & soap	Hydrogen peroxide & soap	Sodium carbonate & sodium bi-carbonate
Ends/cm	24.0 (61)	23.5 (60)	24.5 (62)
Picks/cm	21.7 (55)	22.4 (57)	22.8 (58)

() Values in parenthesis are ends and picks per inch.

Winding Breaks of Tasar Yarns

Winding breaks of tasar yarns during warp bobbins and weft bobbins (pirn) preparation are depicted in Table 4.

It shows a 50 to 55 % reduction of breaks per gram for twisted yarns during warp bobbins winding and a 30 to 35 % reduction for untwisted yarn during weft bobbins winding. Due to the higher pH value in the case of sodium carbonate and soap cooking process, there is severe deterioration of silk fibroin[9,27], which reflects the inferior performance during the winding of warp and weft bobbins before beam preparation. But for the other two techniques, the pH values of the solution are maintained under control conditions[9,27] as given in Table 5.

Earlier research shows that degumming is most effective at a pH above 9.50, but if it exceeds 11.00, silk fibroin gets affected. Similarly, degumming becomes less effective below pH 9.50, and no separation of sericin occurs below 8.00[27]. For Daba, Modal and Railytasar eco-races, similar findings are reported. No significant differences in single cocoon quality, reeling performance, or yarn tensile characteristics are found between yarns produced using sodium carbonate with sodium bi-carbonate, and hydrogen peroxide with soap. In contrast, the use of sodium carbonate and soap method deteriorates the reeling performance and yarn quality[9]. This may be the reason for higher number of breaks during the winding of warp and weft bobbins preparation.

Weaving Performance of Tasar Yarns

The warp and weft break during weaving in handloom are depicted in Table 6.

The data show that both warp and weft breaks are reduced by about 50 % when tasar yarns are produced using either hydrogen peroxide with soap or sodium carbonate with sodium bi-carbonate, compared to sodium carbonate and soap process. A similar trend is observed during winding. The higher pH value of the cooking solution (more than 11.00) likely damages the silk fibroin[9,27], resulting in more weak points in the yarn, which may be the reason for inferior weaving performance.

Fabric Defects

The fabric defects, inclusive of missing ends or picks, hairs and slubs, are assessed visually and summarised in Table 7.

Table 7 shows the total number of fabric defects is reduced by approximately 30–40 % when tasar yarns are produced using either hydrogen peroxide with soap or sodium carbonate with sodium bicarbonate, compared to the sodium carbonate and soap method.

Table 4 — Yarn breaks during winding

Parameter	Warp bobbins (twisted yarn)			Weft bobbins (pirn) (untwisted yarn)		
Cooking process	Sodium carbonate & soap	Hydrogen peroxide & soap	Sodium carbonate & sodium bi-carbonate	Sodium carbonate & soap	Hydrogen peroxide & soap	Sodium carbonate & sodium bi-carbonate
Quantity of yarn (g)	200	200	200	300	300	300
No of breaks	489	219	227	895	628	605
Breaks/g	2.45	1.10	1.14	2.98	2.10	2.02
Breaks/Km*	19.00	8.70	8.90	22.40	13.90	14.80

*Length of yarn was calculated using yarn weight and actual denier

Table 5 — pH value of cooking solution

Cooking process	pH value*
Sodium carbonate & soap	11.50
Hydrogen peroxide & soap	9.80
Sodium carbonate & sodium bi-carbonate	10.40

*Measured by digital pH meter.

Table 6 — Warp and weft break during weaving

Parameter	Cooking process for tasar cocoons		
	Sodium carbonate & soap	Hydrogen peroxide & soap	Sodium carbonate & sodium bi-carbonate
Warp breaks/m*	27	12	13
Weft breaks/m*	39	21	18

*Total fabric woven: 5 m

Table 7 — Defects in tasar fabrics

Defect	Cooking process for tasar cocoons		
	Sodium carbonate & soap	Hydrogen peroxide & soap	Sodium carbonate & sodium bi-carbonate
Missing ends/m	4	2	2
Missing picks/m	2	1	1
Hairs/m	1	1	2
Slubs/m	2	1	1
Total defects/m	9	5	6

*Total fabric woven: 5 m

The number of missing ends (warp) and picks (weft) per meter of fabric is lower in these improved processes. No difference is noticed in the number of hairs and slubs, since these are associated with faults imparted during the yarn production (reeling) process. Due to the significant reduction of yarn breaks, the number of missing ends and picks in the fabric is also lower. So, either sodium carbonate and sodium bi-carbonate or hydrogen peroxide and soap can be used to soften cocoons and achieve better preparatory (winding and warping) and weaving performance.

In conclusion, breaks during winding and weaving (warp and weft) are significantly higher for tasar yarns produced using the sodium carbonate and soap technique, primarily due to their lower tenacity. The high alkalinity of the cooking solution (pH > 11) adversely affects fibroin, creating more weak points along the yarn length. This may be the reason for frequent yarn breaks in the preparatory and weaving processes. As a result, a greater number of missing yarns are found in the fabric, increasing the total defects per unit length (meter). Hairs and slubs remain consistent across all fabric samples, indicating that these are linked to the reeling process rather than cocoon softening techniques. So, tasar cocoons can be softened either by sodium carbonate and sodium bi-carbonate or hydrogen peroxide and soap technique towards better preparatory (winding and warping) and weaving performance. The sodium carbonate and bi-carbonate softening process preserves the natural brown colour of tasar yarns, while the hydrogen peroxide and soap process removes it through oxidative bleaching. Therefore, peroxide softening of tasar cocoons is more suitable when dyeing of tasar yarns or fabrics is planned.

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