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Effect of degree of cocoon drying and cocoon cooking conditions on reeling performance and quality of raw silk of Indian bivoltine hybrid cocoons

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The influence of degree of drying and cocoon cooking conditions on reeling characteristics and quality characteristics of raw silk has been studied using CSR race bivoltine hybrid cocoons. From the results it is observed that degree of drying and cocoon-cooking conditions have significant influence on reelability, raw silk recovery, thread troubles and quality of raw silk. Results indicate that drying of cocoons to the optimum degree of drying and better cocoon cooking conditions are essential for achieving better reeling performance and for the production of superior grade raw silk. Results also reveal that good quality raw silk (of international grade) can be produced from semi-dried cocoons provided cocoon cooking is good with suitable cocoon cooking conditions depending upon targeted raw silk recovery and quality. (*To whom correspondence should be addressed ,Tel +91-8559-222284 , E mail : naikcstri@yahoo.co.in)

Key words: Degree of drying, cooking conditions, Reelability, Thread troubles, Neatness, Cleanness, Elongation, Cohesion

INTRODUCTION

One of the important objectives of cocoon drying is to harden sericin uniformly at filament cross over points so as to achieve uniform cooking of cocoons and uniform resistance to unwinding of cocoon filament during reeling. This is expected to be influenced by the degree of drying. Cocoon drying has been researched extensively at CSTRI to dry the cocoons to the optimum level in the case of both multivoltine and bivoltine hybrid cocoons. Research has also been carried out in Japan and China by varying the temperature and duration profiles in achieving complete drying of the cocoons and its influence on quality of silk (Takabayashi 1992, Kim 1989, Takashi Omura 1981). Complete drying of cocoons is a must in these countries, as cocoons have to be stored for long periods. Whereas in Southern India (Karnataka, Tamilnadu and Andhra Pradesh), cocoons are available throughout the year. Therefore, most of the reelers do not store the cocoons for longer period. This situation leads us to the question whether it is essential to remove the entire water content from the pupal body when the cocoon is not required to be stored for long periods. Information available in this regard is scanty and no published literature is available for Indian cocoons. It is in this context attempt has been made to study the influence of degree of drying and cocoon cooking conditions on reeling performance and quality of raw silk.

MATERIALS AND METHODS

Materials **:** Bivoltine hybrid cocoons (CSR_2 X CSR_4) purchased from the Government. Cocoon market were used for the studies.

Experimental Design **:** The experimental design varied the **Drying conditions** (factor A, 4 level viz A1,A2, A3 and A4) and **Cooking temperature** of two pan cooking

method (factor B, 3 levels viz B1, B2 and B3) .

Cocoon drying **:** Cocoons were hot air dried in CSTRI batch type hot air drier to different degree of drying using following different drying conditions.

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A1		A2	
Temp	Duration	Temp	Duration
115°C	1hour	115°C	1hour
		100°C	1hour

A3		A4	
Temp	Duration	Temp	Duration
115°C	1hour	115°C	1hour
100°C	1hour	100°C	1hour
85°C	1 hour	85°C	1 hour
		70°C	1hour
		55°C	1 hour

The cocoons were weighed before drying and after drying and degree of drying was calculated as follows;

$$\text{Degree of drying (\%)} = \frac{\text{Dry cocoon weight}}{\text{Green cocoon weight}} \times 100$$

The hot air dried cocoons were cooked in two pan by employing the following cooking parameters.

Retting:	B1	B2	B3
Temp.	50°C	50°C	50°C
Duration:	2.0min	2.0min	2.0min
High temperature water treatment			
Temp.	90°C	90°C	90°C
Duration:	2.0min	2.0min	2.0min
Low temperature water treatment			
Temp.	65°C	65°C	65°C
Duration:	1.0min	1.0min	1.0min
Cooking temperature			
Temp.	90°C	93°C	96°C
Duration:	3.5 min	3.5 min	3.5 min
Adjustment treatment			
Temp.	90°C to 80°C	93°C to 80°C	96°C to 80°C
Duration:	4.0 min	4.0min	4.0min

Cooked cocoons were brushed in water at 80°C**.**

Reeling**:** Reeling of cocoons were carried out on CSTRI multiend reeling machine using 100mtrs reeling speed, 8cms croissure length and 40°C reeling basin water temperature. Water having 7.1pH, 70ppm hardness and 80ppm alkalinity was used for the study. Raw silk samples were tested adopting international standard procedure. The data collected were statistically analysed.

RESULTS AND DISCUSSIONS

Degree of drying : Degree of drying of cocoons was 72.9% in case of 115°C (1 hour duration) drying condition, 59.5% in the case of of115°C–100°C(2 hrs duration) , 50.7% in the case of 115°C–100°C - 85°C (3 hrs duration) drying condition of and 43.0% in the case of 115°C - 50°C (5 hours duration) drying condition.

Reeling characteristics:

Reelability

It is observed from the results (Table 1 and 2) that influence of cocoon drying temperature profile and duration on reelability is significant at 5% level, whereas influence of cocoon cooking condition is significant at 1% level. Drying condition of 115°C - 50°C (5 hours duration) associated with 96°C cooking temperature has resulted in better reelability of cocoons. This is attributed to uniform hardening of the sericin of filament cross over points and better cocoon cooking conditions. 115°C (1 hour duration) drying condition associated with cooking temperature of 96°C has also resulted in better reelability.

It is also observed that 90°C cocoon cooking temperature has reduced the reelability significantly in the case of all the drying conditions and this is attributed to under cooking of cocoons.

Raw silk recovery, raw silk percentage and waste percentage

Results indicate that (Table 2) influence of temperature profile of cocoon drying, cocoon cooking temperature (of two pan cooking) and interaction effect of cocoon drying and cocoon cooking temperature is statistically significant at 1% level.

It is observed that 115°C – 50°C (5 hrs duration) drying condition associated with 96°C cooking temperature of two pan cooking method has resulted in better raw silk recovery and hence better raw silk percentage as compared to any other condition. This is attributed to optimum

drying and cooking of cocoons. The temperature profile of 115°C-50°C for cocoon drying has provided required hardening of sericin, whereas two pan cooking method with 96°C cooking temperature has resulted in better cooking of cocoons. Interaction effect of these two parameters have resulted in significantly less waste percentage (Table1) and hence increased the raw silk recovery and raw silk percentage.

Table 1. Effect of cocoon drying conditions and cooking conditions on reeling characteristics of bivoltine hybrid cocoons.

Cocoon drying and cooking parameters	Reelability (%)	Raw silk recovery (%)	Raw silk%	Waste % on silk weight	Thread troubles per 10,000 mtrs silk reeled
A1B1	78.26	75.90	17.95	14.95	5.40
A1B2	80.74	77.93	18.43	14.27	4.49
A1B3	82.58	77.25	18.27	14.47	4.60
A2B1	78.05	75.48	17.85	14.530	4.77
A2B2	79.94	78.60	18.59	13.840	3.34
A2B3	81.10	77.46	18.32	14.070	4.55
A3B1	78.78	78.22	18.50	14.390	4.12
A3B2	79.00	80.34	19.00	12.550	3.70
A3B3	81.17	78.60	18.59	13.800	2.40
A4B1	79.00	78.65	18.60	13.140	2.57
A4B2	80.50	80.76	19.10	12.300	1.25
A4B3	83.81	82.88	19.60	8.640	1.00
CD(P<=0.05) for					
Drying conditions(A)	1.089	0.49	0.117	0.895	0.401
Cookin conditions (B)	0.943	0.43	0.101	0.775	0.348
A x B	1.886	0.85	0.202	1.551	0.695

A - Cocoon drying conditions (A1 - 115°C, 1hr, A2 - 115°C -100°C, 2 hr , A3- 115°-100°C-85°C 3hr A4 - 115°C-100°C-85°C-70°C-55°C, 5hr)

B- Cocoon cooking temperatures (B1- 90°C, B2 - 93°C, B3 - 96°C)

Table 2. Analysis of Variance of Reeling performance results.

Factors		Mean sum of squares				
	Degree of freedom	Reelability	Raw silk recovery	Raw silk%	Waste %	Thread troubles
Drying conditions (A)	3	2.942*	18.661**	1.044**	12.208**	11.759**
Cooking conditions(B)	2	26.774**	12.782**	0.715**	4.724**	2.94**
A x B	6	0.99	1.953**	0.109**	2.994**	0.59**
ERROR	12	0.749	0.153	0.009	0.507	0.102

** Significant at 1% level * Significant at 5% level, ^{NS}Non significant

It is observed that two pan cooking method with 93°C cooking temperature has resulted in better raw silk recovery as compared to 90°C and 96°C cocoon cooking temperatures of two pan cooking in case of 115°C (1hr duration), 115°C-100°C (2 hr duration), and 115°C-100°C-85°C (3 hrs durations) drying conditions. This may be due to the fact that since the cocoons are partially dried, sericin will be having comparatively less resistance to cocoon cooking. Cooking temperature of 96°C might have resulted in over softening of outside silk filament layers leading to generation of more waste percentage.

Thread Troubles during reeling

It is observed (Table 2) that cocoon drying conditions and cocoon cooking temperature have significant (at 1% level) influence on thread troubles during reeling. From the results given in the Table 1 it is observed that Cocoon drying condition of 115°C-55°C (5hr duration) associated with two pan cooking with 96°C cooking temperature has resulted in minimum thread troubles during reeling. This is attributed to uniform hardening of sericin of all the cocoon filaments cross over points in the cocoon shell in the process of cocoon drying and swelling and softening of sericin of these cross over points to a suitable extent in cooking because of better cooking conditions.

Occurrence of thread troubles is significantly on the higher side in the case of semi-dried cocoons in general and 115°C (1 hour duration) and 115°C-100°C (2 hours duration) drying conditions in particular. This may be attributed to the fact that when the cocoons are dried for only one or two hours sericin of cocoon filament cross over points will not be hardened uniformly and variation in sericin resistance to cocoon cooking exists.

Quality characteristics of raw silk:

Neatness of raw silk

Results (Table 3&4) indicate that the temperature profile and duration of cocoon drying do not have any significant influence on neatness of raw silk, whereas its influence on low neatness of raw silk is significant at 1% level. Influence of cocoon cooking temperature of two pan cooking method on both neatness and low neatness of raw silk are significant at 1% level.

Cleanness of raw silk

The influence of cocoon cooking condition and interaction effect of cocoon drying condition and cocoon cooking condition on cleanness of raw silk is significant at 1% and 5% level(Table 4). Results indicate (Table 3) that 115°C – 55°C (5 hours) drying conditions associated with two pan cooking with 96°C cooking temperature of two pan cooking method has resulted in better cleanness of raw silk as compared to other conditions. This is attributed to better cocoon drying and cocoon cooking conditions.

Further results (Table 3) indicate that the semi-dried cocoons with drying conditions of 115°C (1hr duration), 115°C-100°C(2hrs duration), 115°C- 100°C- 85°C (3hrs duration) associated with 96°C cooking temperature have also resulted in good cleanness of raw silk. However, occurrence of thread troubles (due to generation of more slugs and other defects like pelade rupturing and jumping up to buttons etc.,) are significantly at higher side (Table 1) in the case of semi-dried cocoons. Because of appropriate hole size of reeling buttons these cleanness defects are eliminated during reeling, but at the cost of increased thread troubles.

Tenacity of raw silk

Results given in the Table 4 indicate that the cocoon drying conditions and cocoon cooking conditions have significant influence at 5% level and 1% level (Table 4) respectively on tenacity of raw silk. The completely dried cocoons with 115°C – 55°C, (5 hrs durations) drying conditions associated with 96°C cooking temperature has resulted in significantly better tenacity of raw silk as compared to other conditions(Table 3). This is attributed to better drying and cocoon cooking conditions.

Elongation of raw silk

The results (Table 4) indicate that influence of cocoon drying conditions and cocoon cooking conditions have significant influence (at 1% level) on elongation of raw silk It is observed (Table 3) that 115°C

Table 3. Effect of cocoon drying conditions and cooking conditions on quality characteristics of raw silk.

Cocoon drying and cooking parameters	Neatness (%)	Low Neatness (%)	Cleanness (%)	Tenacity (g/d)	Elongation (%)	Cohesion (no. of strokes)
A1B1	90.50	83.00	89.00	3.80	18.00	44.00
A1B2	91.50	83.00	90.00	3.85	19.53	55.00
A1B3	93.00	88.00	95.00	3.92	22.68	83.00
A2B1	90.00	83.00	88.00	3.80	17.80	49.00
A2B2	92.00	83.00	91.00	3.86	19.00	58.00
A2B3	93.00	88.00	95.00	3.94	21.88	90.00
A3B1	89.00	88.50	86.00	3.90	17.60	51.00
A3B2	92.00	88.00	91.50	3.93	18.58	60.00
A3B3	93.00	88.00	96.00	3.98	21.30	122.00
A4B1	88.00	85.00	84.00	3.93	17.50	62.00
A4B2	93.00	85.00	93.00	3.95	19.00	71.00
A4B3	95.00	90.00	98.00	4.10	21.58	149.00

A - Cocoon drying conditions (A1 - 115°C, 1hr, A2 - 115°C -100°C, 2 hr , A3- 115°-100°C-85°C 3hr
A4 - 115°C-100°C-85°C-70°C-55°C, 5hr)

B- Cocoon cooking temperatures (B1- 90°C, B2 - 93°C, B3 - 96°C)

Table 4. Analysis of Variance of Qualty characteristics of raw silk.

Factors	Degree of freedom	Mean sum of squares					
		Neatness	Low Neatness	Cleanness	Tenacity	Elongation	Cohesion
Drying conditions (A)	3	0.444^{NS}	17.375**	0.264^{NS}	0.025*	0.916**	1319.333**
Cooking conditions(B)	2	35.292**	36.292**	171.125**	0.034**	35.757**	8174.000**
A x B	6	2.403^{NS}	4.625**	8.347*	0.001	0.097	376.667**
ERROR	12	1.542	0.958	2.19	0.005	0.178	16.5

** Significant at 1% level, *Significant at 5% level, ^{NS} Non significant

(1 hr duration) drying condition associated with 96°C cocoon cooking temperature has resulted in better elongation of raw silk as compared to other conditions. Decrease in trend of elongation of raw silk is observed as the duration of cocoon drying increases. This is presumably due to increase in crystallinity of sericin and fibroin of raw silk because of heat treatment for longer durations.

Results given in the Table 3 indicate that 90°C cooking temperature of two pan cooking method has affected the elongation of raw silk significantly in the case of all the drying conditions. This is attributed to under cooking condition of cocoons.

Cohesion of raw silk :

It is observed (Table 4) that both cocoon drying conditions and cocoon

cooking conditions have significant (1 % level) influence on cohesion of raw silk.

From the results given in the Table 3 it is observed that 115°C – 55°C, (5 hrs durations) drying condition associated with 96°C cooking temperature of two pan cooking method has resulted in better cohesion of raw silk as compared to other conditions. This is attributed to better cocoon drying and cooking conditions (Naik 1995).

Results given in the Table 3 indicate that 115°C – 55°C, (5 hrs durations) drying condition has given better Cohesion of raw silk as compared to other drying conditions viz. 115°C (1hr duration), 115 °C- 100°C (2hrs duration) and 115 °C- 100°C-85°C (3hrs duration). Increase in trend (table 4) in Cohesion of raw silk is observed as the drying duration increases. This is attributed to increase in crystallinity of sericin of raw silk because of heat treatment for longer durations. It is to be noted that stickiness of sericin increases as the crystallinity of sericin increases leading to better agglutination of filaments in raw silk resulting in better cohesion of raw silk.

CONCLUSION

It may be inferred from the findings that temperature profile and duration of cocoon drying and cocoon cooking conditions have significant influence on reeling performance and quality of raw silk. Results indicate that drying of cocoons to the optimum level and better cocoon cooking conditions are essential for achieving better reeling performance and for production of superior grade raw silk.

Results also reveal that good quality raw silk of international grade can be produced from semi-dried cocoons provided cocoon cooking is good. However, to achieve better raw silk recovery and productivity from semi-dried cocoons selecting suitable cocoon cooking parameters is critical and these are dependent on targeted raw silk recovery and grade of raw silk.

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