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# Influence of cocoon stifling and storage on silk reeling performance and quality of muga raw silk

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The hot air electrical stifling study has been conducted to evaluate the influence of electrical stifling temperature, stifling hours and duration of cocoon preservation on reeling performance and quality of muga silk . Muga cocoons are reeled on motorised muga silk reeling machine. Electrical hot air stifling has shown superior reeling performance in comparison to smoke stifled and sun dried cocoons. The study has shown that raw silk recovery from electrically hot air stifled cocoons is significantly high in comparison to flame-smoke-sun stifling with a gain of about 6.37%. Similarly there is gradual decline in raw silk recovery (RSR) percentage with increase in storage period of muga cocoon. Thus, RSR has declined by 14.32% in course of 6 months of cocoon storage. Tenacity is found higher in October crop (average 3.36 g/den), while it is average 2.83 g/den in crop of May month. Muga raw silk yarn has lost elongation with extended storage of yarn. In fresh muga raw silk yarn, elongation is found 37.55%, while in one year old stored muga raw silk yarn elongation has come down to 33.02%. Thus, the study recommends stifling muga cocoon by hot air stifling for four hours. Cocoon preservation time needs to be minimized and muga silk yarn of October (Kotia) crop with high tenacity should be used as warp yarn in weaving.

**Keywords**: Cocoon, Stifling, Muga raw silk, Raw silk recovery, Silk reeling, Tenacity

The golden yellow muga silk yarn produced by muga silk worm (*Antheraea assamensis*) was exclusively being produced in North East Indian state of Assam and adjoining areas. It is considered to be most expensive natural commercial textile fibre[1]. Presently, 1 kg of muga raw silk yarn costs about Rs 17500-20000. Commercial muga cocoons are available only during two seasons in a year, viz once during April-June (Jethua crop) and again during October – December (Kotia crop)[2]. Presently, there is a practice to stifle muga cocoons by exposing them to smoke for about half an hour followed by drying them in sun for about 15 days. This elaborate process has its own problems, i.e. blackening of cocoons, losses during prolonged sun drying and damage due to ultra violet rays[3].

This study was initiated with an objective of overcoming the problems of conventional stifling. The electrical stifling was done to evaluate the influence of electrical stifling temperature, stifling duration and cocoon storage on reeling performance and silk quality. To the best our knowledge, hardly any information is available on stifling and storage of muga cocoons and their influence on muga silk recovery and muga raw silk quality. The present investigation was therefore undertaken to study the influence of muga cocoon stifling process using electrical dryer with respect to temperature and duration on the reeling performance; to optimize the stifling process for obtaining maximum raw silk using minimum energy, to study the muga cocoon storage duration and understand its influence on reeling performance; and to optimize the cocoon storage conditions for better maintenance of reeling performance.

## Experimental

Four commercial crops of muga cocoons were used with ratio of two crops per year. In each crop, 10,000 numbers of cocoons were procured for study. Conventional barrel furnace type smoke drying system was used for stifling. The 50 kg capacity electrical hot air stifling chamber was used for cocoon drying. Cocoons were stored in wire mesh cage with perforated trays. Each rack was having capacity to store 10,000 cocoons. Cooking was done by open pan cocoon cooking device[4]. In cooking bath, water was taken in cocoon: water ratio of 1:10 (by weight). Washing soda was added for cooking cocoons at the rate of 2 g/L of water. Cooked cocoons were reeled on motorised muga silk reeling cum twisting machine developed by Central Silk Technological Research Institute, Central Silk Board, India.

### Test Methods

Five cocoon storage periods, viz 1 day, 3 days, 30 days, 90 days and 180 days were taken for study. Five types of drying treatments were studied. The

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electrical hot air drying schedules were examined in duration of 1-4 h. In electrical hot air stifling, temperature was taken in decreasing order of 110ºC, 100ºC, 90 ºC and 80 ºC per hour respectively[5]. However, the conventional stifling was done with smoke flame by keeping cocoons above open-ended tin barrel for about 30 min to kill pupa followed by prolonged drying. Raw silk recovery (%) and absolute silk content were calculated as follows:

$$\text{Raw silk recovery (\%)} = \frac{\text{Weight of silk yarn reeled}}{\text{Absolute silk content}} \times 100$$

Absolute silk content = Number of cocoons in lot × average shell weight

## Results and Discussion

The commercial characteristics of muga cocoon for each crop have been studied. In each year, October (Kotia) crop has shown superior commercial cocoon characters in comparison to May (Jethua) crop (Table 1).

### Weight Loss in Cocoon on Stifling

The influence of various stifling temperature and duration has been studied. The electrically hot air stifled cocoons are weighed after 24h of stifling to facilitate proper cooling of cocoons. The weight loss in conventionally flame-smoke stifled cocoon has been taken after 15 days of sun drying as practiced commonly. The weight loss in cocoon is indicated in Table 2.

### Influence of Drying Method & Cocoon Storage Period on Reeling Performance

The electrical hot air stifling has shown superior reeling performance in comparison to conventional smoke stifled and sun dried cocoons. The average RSR in electrical stifled cocoon is found 39.84%, while in conventional stifling it is 37.45%. Thus, electrical hot air drying has shown RSR% higher by 2.39. This shows a gain of 6.37% upon conventional stifling, Similarly there is gradual decline in RSR% with increase in storage period of muga cocoon, irrespective of the method of stifling adopted. Average RSR for 4h dried cocoons reeled after 1 day, 3 days, 30 days, 90 days and 180 days of stifling are 48.56,42.84,38.35,35.95 and 34.24% respectively. Thus, raw silk recover (RSR %) has declined by 14.32% in course of 180 days of storage. This shows a loss of 30.45% upon one day old stifled muga cocoons (Table 3).

### Influence of Cocoon Storage Period on Waste Generation

With the increase in muga cocoon storage period, the amount of reeling waste generated keeps on increasing significantly. The average visible reeling waste generated by one day old cocoon is found 42.44 %, which is then, increased to 47.68% in 180 days old stifled cocoons, with rise of 5.25 %.

### Influence of Stifling and Storage on Muga Raw Silk Quality

Upto 180 days storage, raw silk quality is not influenced in respect of tenacity (g/den). However, tenacity has shown significant variation in October

Table 1 — Commercial characters of muga cocoon

| Trial | Crop | ACW, g | ASW, g | AFL, m | NBFL, m | Fw, g | Denier | R,% |
|---|---|---|---|---|---|---|---|---|
| Trial 1 | Oct ,2013 | 5.20 | 0.480 | 415.32 | 146.62 | 0.258 | 5.60 | 35.30 |
| Trial 2 | May,2014 | 4.83 | 0.408 | 344.90 | 117.16 | 0.241 | 6.28 | 33.97 |
| Trial 3 | Oct, 2014 | 5.60 | 0.510 | 430.13 | 184.98 | 0.280 | 5.86 | 43.01 |
| Trial 4 | May,2015 | 4.80 | 0.320 | 318.00 | 102.00 | 0.210 | 5.94 | 32.08 |

ACW − Average cocoon weight, ASW− Average shell weight, AFL − Average filament length, NBFL− Non broken filament length, and Fw −Filament weight.

Table 2 — Weight loss in Muga cocoon on various drying treatments

| Drying code | Temperature, ºC | | | | Weight loss, % |
|---|---|---|---|---|---|
| | 1h | 2h | 3h | 4h | |
| D1 | 110 | - | - | - | 8.78 |
| D2 | 110 | 100 | - | - | 19.85 |
| D3 | 110 | 100 | 90 | - | 31.46 |
| D4 | 110 | 100 | 90 | 80 | 33.55 |
| D5 | Conventional : Smoke killing & 15 days sun drying | | | | 35.29 |

ANOVA

| Source | Dependent variable | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|---|
| Drying, h | loss % | 10145.710 | 4 | 2536.427 | 296.281 | 0.000 |

1h, 2h, 3h and 4h are drying hours.

Table 3 — Change in muga raw silk recovery (%) with stifling and storage period

| Storage days | Hot air stifling | | | | Conventional smoke+sun | Gain % in 4 h in terms of absolute silk content |
|---|---|---|---|---|---|---|
| | 1 h | 2 h | 3 h | 4 h | | |
| 1 | 46.14 | 46.46 | 46.86 | 48.56 | 42.19 | 6.37 |
| 3 | 41.88 | 41.94 | 42.10 | 42.84 | 40.10 | 2.74 |
| 30 | 37.56 | 37.77 | 38.05 | 38.35 | 35.49 | 2.86 |
| 90 | 35.21 | 35.29 | 35.36 | 35.95 | 35.04 | 0.91 |
| 180 | 32.25 | 32.30 | 32.50 | 34.24 | 31.22 | 3.02 |
| Loss % in terms of absolute silk content | 13.89 | 14.16 | 14.36 | 14.32 | 10.97 | |

ANOVA

[Dependent variable- RSR (%)]

| Source | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Model | 157683.062[a] | 9 | 17520.340 | 347.242 | 0.000 |
| Drying_(h) | 101.144 | 4 | 25.286 | 0.501 | 0.735 |
| storage_cd | 2554.919 | 4 | 638.730 | 12.659 | 0.000 |
| Error | 4591.468 | 91 | 50.456 | | |
| Total | 162274.530 | 100 | | | |

$R^2 = 0.972$ (adjusted $R^2 = 0.969$).

Table 4 — Influence of crop on tenacity and elongation %

| Crop | Tenacity , g/den | Elongation, % |
|---|---|---|
| Oct , 2013 | 3.36 | 33.62 |
| May, 2014 | 3.07 | 32.42 |
| Oct, 2014 | 3.35 | 36.68 |
| May, 2015 | 2.59 | 38.41 |

ANOVA

| Source | Dependent variable | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|---|
| Crop | Tenacity, g/den | 9.723 | 3 | 3.241 | 57.784 | 0.000 |
| | Elongation, % | 567.052 | 3 | 189.017 | 13.729 | 0.000 |

(Kotia) and May (Jethua) crops[6]. The average tenacity of raw silk yarn is found to be 3.09 g/den. Tenacity is found higher in October crop (average 3.36 g/den), while it is 2.59 g/den in crop of May month. There has been a reduction in elongation of yarn with lapses of yarn storage time. The testing of all yarn is done during Nov- Dec 2015, and the yarns of cocoon crop (Oct13 & May 14) has the average elongation of 33.02 %, while that of Oct 14 & May 15 has the average elongation of 37.55 %. Thus, it can be assumed that there is a significant loss in elongation % by lapse of about one year of time in yarn storage, (Table 4).

Electrical drying of muga cocoons upto 4h has shown favourable results on reeling performance in terms of raw silk recovery (RSR %) and reeling waste (%). Storage of muga cocoon upto 180 days reduces raw silk recovery (RSR%) and increases the quantity of reeling waste. Yarn quality in terms of tenacity and elongation has not been influenced till six months of cocoon storage. Electrical hot air stifling of muga cocoon should be commercially adopted on mass scale in muga cocoon growing places.

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