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Impact of High Temperature during Chawki Stage on the Post Cocoon and Reeling Parameters of Silkworm *Bombyx mori* L.

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ABSTRACT: Temperature plays a pivotal role in determining the growth and development of silkworm. Good quality cocoons are produced within an optimum temperature range. Young age silkworms considerably prefer higher temperature than late age silkworms. The wide fluctuations in temperature harshly influence the physiology, growth and development of silkworm. In this study, an attempt was made to study the impact of temperature above optimum level, during chawki stage on the post cocoon and reeling parameters of silkworm. In this study, significant decrease in several parameters *viz.*, reelability, raw silk percentage, denier, filament length, non-breakable filament length, effective rate of rearing and cocoon yield by number and by weight when silkworms were exposed to high temperature during chawki rearing. However, considerable increase in all parameters was observed when silkworms were reared on optimum temperature (control group). Hence, temperature fluctuations during the chawki stage had an immense effect on the post cocoon and reeling parameters of the silkworm. This study emphasizes the need of maintenance of optimum temperature during the chawki stage for quality and quantity raw silk production.

Keywords: Silkworm, chawki rearing, high temperature, reelability.

INTRODUCTION

Sericulture is traditional cottage industry of India. It has been adopted as a small-scale occupation in several nations, including China, India, Brazil, Japan, Russia, Korea, France and Italy (Bhat *et al*., 2020). After China, India is the world's second-largest producer ofraw silk and the world's leading consumer of raw silk and silk textiles (Sarkhel *et al.*, 2017). The silkworm, *Bombyx mori*, has been domesticated for nearly 4,000 years and has diminished many of its initial powers such as its ability to smell, fly, etc. Hence, it is completely within the care of silkworm rearers (Khan, 2014). Genetically, silkworm can complete number of generations in a year. However, environmental factors such as temperature, humidity, photoperiod, and so on are known to have an effect on the silkworm throughout its entire life span (Khan, 2014). Temperature, humidity, rearing season, and mulberry quality all have an impact on biological and cocoon characteristics (Hussain *et al.*, 2011). Seasonal variation has a significant impact on the cocoon production and manifestation of any reduction in cocoon yield owing to disease incidence (Rahmathulla, 2012). Several silkworm characteristics are regulated not only by genes, but also by external variables like temperature and relative humidity. High temperatures have an impact on practically all biological processes, especially the rates of biochemical and physiological reactions (Hazel, 1995; Willmer *et al.*, 2004), affecting both the quantity and quality of cocoon crop production. Investigators (Tazima and Ohnuma 1995; Hussain *et al.*, 2011) found that the larvae of silkworms are susceptible to high temperatures (over 25 ± 1˚C) during the 4th and 5th instars and the lower or higher levels of relative humidity also have significant impact on their growth and development. According to Kumar *et al.* (2003), unfavorable environmental circumstances throughout silkworm rearing not just affect overall rearing performance, culminating in low yield, however have an impact on post-cocoon variables, culminating in low silk output and quality. The success of silkworm rearing largely depends on the quality of silkworm rearing. The optimum temperature required for silkworm during young age varies from 28±2˚C and for late age (24-25˚C) is optimized (Rahmathulla, 2012). A silkworm prefers different temperature ranges according to the stage of larva being reared. The young age silkworms usually show lower levels of temperature tolerance than late age worms (Qadir *et al.*, 2022). Lack of skill and rearing technicalities pose a threat of higher disease incidence at farmer level. Hence, it forms a major obstacle for an average farmer to rear silkworms from early age.

Cocoon quality factors have a significant impact on the grade of raw silk reeled. A variety of characteristics determine the cocoon quality such as, silkworm race,

rearing technique adopted, quality of mulberry leaf fed, environmental conditions maintained and hygiene during rearing. The quality of biological and cocoon features of silkworm are directly related to the post cocoon parameters. The technical features of the cocoon are critical for a reeling technologist because they influence the quality, quantity, and effectiveness of the reeling process (Gowda and Reddy 2006). It is stated that reeling with uneven cocoons causes thread breakage, slug impediment, poor reelability, poor cooking, reduced raw silk recovery, fluctuation in raw silk denier, and poor neatness (Takabayashi *et al.*, 1997). Different investigations on temperature variances and their impact on cocoon production elucidate the challenges at farming level in successful management of early age silkworm rearing. In previous study, significant increase in larval weight, disease incidence, defective cocoon percent and decrease in larval duration, cocoon weight, shell weight and shell ratio were recorded when high temperature was induced during early age silkworm rearing (Qadir *et al*., 2022). With the goal of comprehending the impact of high temperature during chawki rearing on cocoon characteristics, this study was envisaged to explore the impact of high temperature during chawki rearing on the and post cocoon and reeling parameters of silkworm *Bombyx mori* L.

MATERIAL AND METHODS

The current study was carried out at the research laboratory of Regional Sericultural Research Station, Miran Sahib, Jammu during spring 2017. The eggs of the silkworm double hybrid (FC1×FC2) were obtained from SSPC, Udhampur (J & K), and incubated at the specified temperature of 25ºC and 80% humidity. The silkworms were split into two distinct groups after brushing. During the chawki stage, the first group was raised at a high temperature of 30±2ºC, while the second group was kept at a standard temperature (control) (Jolly, 1987). Afterward, both silkworm groups were kept in typical environments in accordance with the rearing schedule given by Krishnaswami (1978). The cocoons were harvested and sent to Silk Technical Service Centre, Central Silk Board, Miran Sahib, Jammu for obtaining the data on different silk reeling parameters.

Effective rate of rearing by number (ERRn): ERRn was computed on the basis of the larval count at the 4th stage just after the 3rd molt (Joshi, 1985) and was calculated by the following formula

$$\text{ERRn (\%)} = \frac{\text{Total number of harvested cocoons}}{\text{Total number of worms retained}} \times 10,000$$

Effective rate of rearing by weight (ERRw): ERRw was computed on the basis of weight of total harvested cocoons from each group measured on electronic balance. It was calculated accordingly by the following formula (Joshi, 1985).

$$\text{ERRw (\%)} = \frac{\text{Total weight of harvested cocoons}}{\text{Total number of cocoons harvested}} \times 10,000$$

Filament length: It refers to total filament length reeled from the cocoon. Ten boiled silk cocoons from each group were reeled on an Eprouvette and the total filament length for each cocoon was measured in meters (m). The total filament length was calculated by using the following formula.

$$\text{Filament length (m)} = \frac{\text{Total filament length reeled}}{\text{Total number of cocoons reeled}}$$

Non-breakable filament length: Non-breakable filament length is the average length of a cocoon's filament that is capable of being unraveled continuously.

$$\text{NBFL} = \frac{\text{weight of filament length}}{1 + \text{number of breaks}}$$

Denier: Denier is defined as the strength of silk thread. The reeled silk thread was taken from the Epprouvette. The weight of reeled silk was recorded after drying it for fifteen days. The denier was calculated by using the following formula (Evans, 1939).

$$\text{Denier} = \frac{\text{Weight of silk filament (g)}}{\text{Length of single cocoon filament (m)}} \times 9000$$

Raw silk percentage: The raw silk percentage is the ratio of the amount of raw silk reeled to the number of fresh cocoons utilized for reeling purpose

$$\text{Raw silk \%} = \frac{\text{Number of cocoons reeled}}{\text{Number of feeding ends}} \times 100$$

Statistical analysis: The data collected for different parameters was arrayed and means were compared by paired sample t-test using the SPSS version 19.0.

RESULTS

A significant decrease in reelability percent (T= -6; P= 0.02) and an increase in raw silk percent (T=-4.38; P= 0.04) when chawki worms were exposed to high temperatures. However, a significant increase in reelability percent (87 %) and raw silk percent (40.83 %) was recorded in control as depicted in Fig. 1.

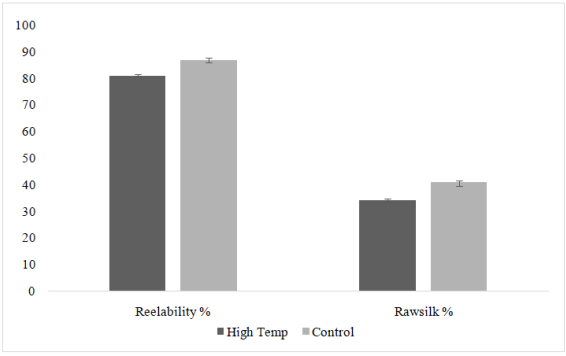

Fig. 1. Effect of different temperature treatments during chawki rearing on the reelability percent and raw silk percent of silkworm cocoons.

When chawki worms were subjected to high temperatures, decrease in denier (T = -4.71; P = 0.04) and increase in rendita (T = 4.73; P = 0.04) was recorded and significant increase in denier and decrease in rendita was recorded in control as depicted in Fig. 2.

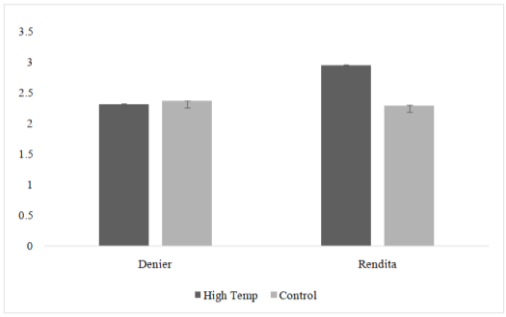

Fig. 2. Effect of different temperature treatments during chawki rearing on the rendita and denier.

Decline in filament length (T = -13.11, P = 0.00) and non-breakable filament length (T = -10.88, P = 0.00) was recorded when worms were exposed to high temperatures during chawki stage. However, a significant increase in filament length (1185 m) and non-breakable filament length (927.66 m) was recorded in control as illustrated in Fig. 3.

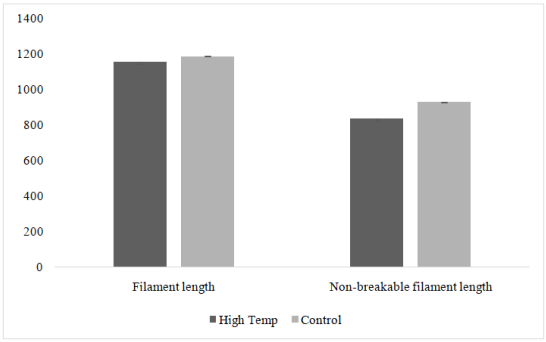

Fig. 3. Effect of different temperature treatments during chawki stage on the filament length and non-breakable filament length.

A decrease in ERR % (T= -23.26; P=0.00), Yield/1000 larvae by weight (T= -17.21; P=0.00), and Yield/1000 larvae by number (T= -13.06; P=0.00) was recorded when silkworms were exposed to high temperature during chawki rearing. However, a significant increase in ERR %, Yield/1000 larvae by weight, and Yield/1000 larvae by number was observed in the control as shown in Table 1.

Table 1: Effect of different temperature treatments during chawki rearing on the ERR percent and Cocoon yield of silkworm.

Treatments	ERR %	Cocoon Yield/1000 larvae by weight	Cocoon Yield/1000 larvae by number
High Temp	40.38 ± 1.46	8.56 ± 0.23	4075.66 ± 413.11
Control	87.37 ± 0.88	18.72 ± 0.35	8774.33 ± 85.52

DISCUSSION

The growth and development of silkworms is greatly influenced by abiotic factors *viz.*, temperature and humidity. The management of temperature and humidity is necessary for the creation of the optimum environment required for luxuriant and successful cocoon crop production (Rajan *et al.*, 1995; Datta *et al.*, 2013). It is evident that young-age silkworms prefer relatively higher temperatures than late-age silkworms. Maintenance of temperature 27-28° C and relative humidity 80-90% are ideal for young-age silkworm rearing (Krishnaswamy, 1978; Jolly, 1987; Datta *et al.*, 2013). Temperature is one of the abiotic variables that have a significant impact on silkworm growth and output (Benchamin and Jolly 1986). Study conducted by Kant *et al*. (2022) on abiotic and biotic factors, concluded that Climate variables, specifically temperature and humidity, were found to be strongly connected with grasserie incidence and had an impact on total cocoon yield during autumn. Cocoon yield was found to be positively and significantly impacted by temperature, but not significantly by humidity or rainfall during spring. Many Studies have been conducted by many authors (Gowda and Reddy 2006; Hussain *et al.*, 2011; Kumari *et al.*, 2011; Vasudha *et al.*, 2006) indicating the effect of high temperature during different larval stages of silkworms and their subsequent impact on the cocoon and reeling parameters. A perusal of the literature reveals that little work has been carried out on the effect of high-temperature fluctuations during the chawki stage on cocoon production. The young age silkworms usually show lower levels of temperature tolerance than late-age worms (Vasudha *et al.*, 2006; Qadir *et al.*, 2022). A little increase in temperature during the chawki stage may affect growth, development of later stages, and eventually post-cocoon parameters. The current investigation was carried out to emphasize the impact of high temperatures during chawki rearing on the reeling parameters of silkworm cocoons. In this study reelability, raw silk percentage, and denier were found to decrease when silkworms were reared at high temperatures in comparison to the control group. These results were in line with the study conducted by Gowda and Reddy (2006) who found minimum reelability, raw silk percentage, and denier when the high temperature was induced during silkworm rearing. Since the uniform filament size is very crucial from the reeling point of industry (Mano, 1993). Any change in environmental conditions during rearing is responsible for the structural changes of the cocoon. The variations in reelability, raw silk percentage, and denier are attributed to the temperature variations during rearing. Filament length was observed to be lower than the control group when high temperature was maintained during the chawki stage. Similar results were observed by Hussain *et al*. (2011) who found a decrease in filament length when temperature was increased during rearing. This is attributed to the changes in all biochemical changes and physiological reactions (Hsieh

et al., 1995; Willmer *et al*., 2004) during the larval stage which directly influence cocoon quality and quantity and ultimately the post-cocoon parameters including filament length as well. In the high-temperature group, a lower cocoon yield per 1000 larvae was obtained when compared with control. The current results were found in line with the results of Kumari *et al.* (2011) who investigated that all the bivoltine breeds reared at high temperatures showed a decline in cocoon yield per 1000 larvae by weight as compared to control. In this study, an effective rate of rearing (ERR %) also declined in the high-temperature group and similar results were found in the study conducted by Vasudha *et al.* (2006) who investigated that ERR percent was higher at 25°C and declined with the rise of temperature during silkworm rearing. The decline post cocoon parameters may be attributed to the high temperature maintained during silkworm rearing because many quantitative parameters decline sharply when the temperature is higher than 28°C (Kumari *et al.,* 2011).

CONCLUSIONS

In the current study, temperatures over the optimal range resulted in decline reeling and post cocoon parameters *viz*., reelability, raw silk percentage, denier, filament length, cocoon yield per 1000 larvae by weight and number and effective rate of rearing (ERR%). Therefore, maintenance of optimum conditions throughout the chawki stage is of utmost importance to achieve uniform, successful and high-quality raw silk production.

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Conflict of Interest. None.

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