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MICROCLIMATE REQUIREMENTS FOR EFFECTIVE SILKWORM EGG INCUBATION

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Abstract. Silkworm egg incubation is a decisive stage in sericulture because the number, physiological condition, and synchronization of newly hatched larvae directly influence subsequent rearing and cocoon production. This study systematizes the principal microclimatic requirements for the incubation of Bombyx mori eggs and formulates engineering requirements for an automated incubator control system. The analysis focuses on temperature, relative humidity, carbon dioxide concentration, ventilation, spatial uniformity, and the interaction among these parameters.

Keywords: Bombyx mori, silkworm eggs, incubation, microclimate, temperature, relative humidity, CO_2, ventilation, automated control, synchronous hatching.

Natural silk remains a valuable textile raw material because of its high strength, low mass, hygroscopicity, and characteristic luster. Its production begins with the biological development of the domesticated silkworm (Bombyx mori), and the quality of the final silk product depends on a chain of mutually connected technological stages. Among these stages, egg incubation is one of the earliest and most critical. A high-quality cocoon crop requires not only suitable feeding and larval rearing conditions, but also a sufficient number of healthy larvae that hatch within a narrow time interval. If hatching is irregular, larvae of different physiological ages must be reared together, which complicates management and may reduce uniformity in later developmental stages.

The incubation result is strongly determined by the microclimate surrounding the eggs. Temperature regulates the rate of embryonic metabolism; relative humidity affects water balance and the physical condition of the egg shell; and air exchange supplies oxygen while preventing excessive accumulation of metabolic carbon dioxide. These factors do not act independently. Heating changes relative humidity, while ventilation simultaneously affects temperature, moisture, and gas composition. Therefore, an incubator should be regarded as an integrated microclimatic system rather than as a chamber in which separate parameters are adjusted independently.

A further engineering problem is spatial non-uniformity. In a multilayer chamber, heat sources, humidification devices, natural convection, and forced airflow can produce different conditions at different vertical and horizontal positions. Consequently, eggs located in separate zones may develop at different rates even when the average chamber temperature and humidity appear

acceptable. The purpose of this study is to synthesize the biological and technological requirements of Bombyx mori egg incubation and to define a set of control criteria that can serve as the basis for an automated mechatronic incubator.

The methodological approach consisted of four stages. First, the biological role of incubation in the silk production chain was identified. Second, the effects of the principal environmental parameters on embryonic development were analyzed. Third, technological ranges and control criteria were extracted and compared in terms of their relevance to stable and synchronous hatching. Finally, these requirements were transformed into engineering specifications for an automated system. Three general criteria were used for each active parameter: (1) maintenance within an appropriate range, (2) temporal stability, and (3) spatial uniformity within the incubator working volume.

For the engineering formulation, temperature was considered within the 24-26 °C working range and relative humidity within 75-85%. A CO_2 concentration of 2000 ppm (0.20%) was treated as a technical control threshold for ventilation rather than as a universal biological toxicity limit. Light-dark management was considered a technological aid for hatching synchronization, whereas temperature, humidity, and CO_2 were treated as the main active variables for automatic regulation. The resulting specifications were assessed from the viewpoint of coordinated heating, humidification, ventilation, real-time monitoring, minimization of human intervention, and energy-efficient operation.

The analysis confirms that incubation is a determining stage in the production of uniform and viable silkworm larvae. Under appropriate conditions, Bombyx mori embryonic development generally proceeds over approximately 9-12 days, although the exact duration depends on breed, voltinism, previous diapause treatment, temperature, and humidity. Because the silkworm is ectothermic, embryonic development responds directly to environmental temperature. Within the recommended working range, metabolic processes can proceed in a balanced manner. Temperatures that are too low delay development and widen the hatching period, whereas excessive temperatures may accelerate development abnormally and increase the probability of weak or defective larvae.

Relative humidity is the second key parameter. The egg exchanges moisture with the surrounding air through its shell, and insufficient humidity increases water loss. The analyzed material identifies 75-85% RH as a practical incubation range. Adequate humidity becomes especially important near hatching because it helps prevent excessive drying and facilitates emergence of the young larva. At the same time, excessive moisture and condensation may deteriorate sanitary conditions. Therefore, humidity control must prevent both dehydration and local over-wetting.

Gas exchange is also essential. Developing embryos consume oxygen and release carbon dioxide through the chorion. In a closed chamber containing a large quantity of eggs, insufficient ventilation can create conditions for CO_2 accumulation and reduced air renewal. For control-system design, maintaining CO_2 below 0.20% provides a practical criterion for ventilation activation. Ventilation has a dual role: it renews the gaseous environment and also participates in redistribution of heat and moisture. Consequently, excessive or poorly distributed airflow may itself disturb the desired microclimate.

Parameter	Recommended/Control Range	Main Function	Control Requirement
Temperature	24-26 °C	Controls embryonic development rate	Stable and spatially uniform
Relative humidity	75-85% RH	Maintains egg water balance	Stable; avoid drying/condensation
CO_2	< 0.20% (2000 ppm)	Technical ventilation criterion	Continuous monitoring and air renewal
Airflow / ventilation	Controlled, uniformly distributed	Renews gases and redistributes heat/moisture	Coordinated with heating and humidification

A central result of the analysis is that acceptable mean values alone cannot guarantee uniform incubation. Microclimatic parameters must also be distributed as evenly as possible throughout all egg layers. In multilayer incubators, natural convection and the positions of heaters, humidifiers, and fans can generate vertical gradients. Eggs exposed to different local temperatures and humidity levels may consequently reach developmental stages at different times. Spatial uniformity should therefore be treated as an independent design objective alongside set-point accuracy and temporal stability.

The derived engineering requirements are: maintenance of temperature, humidity, and CO_2 within the selected ranges; stable regulation over time; uniform distribution across the working chamber; coordinated operation of heating, humidification, and ventilation devices; real-time sensing and automatic control; reduced dependence on manual intervention; and achievement of the required regime with minimum reasonable energy consumption. These requirements

support the use of a unified control algorithm rather than isolated on/off regulation of individual devices.

The results indicate that the main challenge in silkworm egg incubation is not simply producing heat or moisture, but creating a homogeneous and dynamically balanced environment. This distinction is important for mechatronic incubator design. A controller may hold a temperature sensor near the set point while other zones of the chamber remain warmer or cooler. The same limitation applies to humidity and gas concentration. Therefore, sensor placement, air circulation, actuator coordination, and chamber geometry should be considered together when evaluating system performance.

The interaction between temperature and humidity demonstrates why independent control loops can be insufficient. When air temperature rises while absolute moisture remains unchanged, relative humidity decreases. Similarly, ventilation introduced to reduce CO_2 can remove heat and moisture from the chamber. A coordinated algorithm should therefore respond to the combined state of the system and avoid corrective actions that improve one variable while driving another outside its desired range. Such coordination is particularly relevant near the hatching stage, when both moisture conditions and synchronization are critical.

The use of 2000 ppm CO_2 as a control threshold should be interpreted carefully. In the analyzed material it is defined as an engineering criterion for preventing excessive accumulation in the closed incubator and for triggering ventilation; it is not presented as a universal biological limit for Bombyx mori. This distinction is important when transferring the proposed control logic to incubators of different volumes, egg loads, or ventilation capacities. Future experimental work should therefore validate the threshold together with airflow rate, chamber geometry, sensor locations, and biological outcomes such as hatching percentage and synchronization.

Conclusion. Effective incubation of Bombyx mori eggs requires a controlled microclimate in which temperature, relative humidity, and gas exchange are maintained not only at appropriate average values but also with sufficient temporal stability and spatial uniformity. The analyzed technological requirements support a working temperature of 24-26 °C, relative humidity of 75-85%, and a CO_2 control criterion below 0.20%. Because heating, humidification, and ventilation are mutually interacting processes, they should be managed through a coordinated automatic control strategy. Spatial uniformity is especially important in multilayer incubators, where local gradients can disturb embryonic development and hatching synchronization. Thus, real-time sensing, coordinated actuator control,

minimized human intervention, and energy-conscious operation form the principal technological basis for an improved silkworm egg incubator.

References:

1. Central Silk Board. The Central Silk Board Silkworm Seed Regulations, 2010. – Bengaluru: Central Silk Board, Ministry of Textiles, Government of India, 2010. – URL: https://csb.gov.in/sites/default/files/downloads/CSB-Silkworm-Seed.pdf
2. Prakash B.K., Sannappa B., Manjunatha H.B. Influence of black boxing on the manifestation of economic characters in Bombyx mori // Journal of Sericulture & Technology. 2012. – Vol. 3, № 1–2. – P. 53–56.
3. Rajeshwari N.K., Sannappa B., Manjunatha H.B. Impact of different incubation methods on the growth and cocoon characteristics of Bombyx mori // Journal of Sericulture & Technology. 2011. – Vol. 2, № 2. – P. 155–159.
4. Rahmathulla V.K. Management of climatic factors for successful silkworm (Bombyx mori L.) crop and higher silk production: A review // Psyche: A Journal of Entomology. 2012. – Vol. 2012. – Article ID 121234. – P. 1–12.
5. Rajeshwari N.K., Sannappa B., Manjunatha H.B. Impact of different incubation methods on the growth and cocoon characteristics of Bombyx mori // Journal of Sericulture & Technology. 2011. – Vol. 2, No. 2. – P. 155–159.
6. Kumar N.S., Singh H., Saha A.K. On the implications of temperature and humidity on egg hatching in the commercial silkworm, Bombyx mori L. // International Journal of Life Sciences Research. 2016. – Vol. 4, No. 3. – P. 74–80.