CHAPTER 1

INTRODUCTION

Silk is a natural fibre secreted by sericigenous insects of the order Lepidoptera of phylum Arthropod including silkworms, beetles, spiders, honey bees, scorpions, hornets, mites, flies, and many others invertebrates (Altman et al., 2003). The secretion is used by the insects to provide structural support to protect itself during metamorphosis and it is also used for the formation of cocoons (protective shelter), webs to capture food (Breslauer and Kaplan, 2002). Silk is regarded as a luxurious and the most elegant fabric in the world because of its softness, high moisture absorbance quality, natural sheen, excellent affinity for dyes, light weight and high durability (Samanta et al., 2015).

Silk has played an important role in uplifting the economy and civilization ever since it was discovered. Silk is known as the "Queen of Textiles" and it has remained as the most important fibre even after the discovery of other synthetic man-made fibres. Silk is universally preferred for its elegance, sheen and colour although it is produced in smaller quantities as compared to the other fibres (Babu, 2018).

Sericulture is a deliberate large-scale rearing of silk producing organisms to obtain silk and it is an important tool for the economy of rural areas because it generates high employment opportunity and requires low investment while yielding high returns (Meenal and Ranjan, 2006). Sericulture is a source of income and employment in rural areas, particularly for women in several communities. Because of its low investment, short gestation period, high guaranteed returns, and rich opportunities for income enhancement all year round, sericulture suits both marginal and small-scale landowners (Bukhari et al., 2019). In the current scenario, the sericultural sector is also regarded as an excellent cottage industry as it is agro-based, industrial structure, and labor-intensive industry. It provides employment at various levels like host-plant cultivation, rearing of silkworm, reeling, spinning, weaving, and marketing of silk and other by-products. It is one of the most important sectors of Indian economy which helps in poverty alleviation programs. Sericulture provides full time or part time employment to the people of rural areas of the country (Dewangan, 2018).

Several socio-economic studies have confirmed that the benefit and cost ratio in sericulture is highest among agricultural crops (Ramana, 1987). The country's sericulture industry employs around 9.76 million people in rural and semi-urban areas. The industry is one of the largest foreign exchange earners for the country. The sericulture activities in India are spread across 52,360 villages. A total of 47 species of silkworms are recorded from India, out of which 24 are reported from the North East region (Singh and Suryanarayan, 2005). India is the second-largest producer of silk in the world and the silk industry has been a major contributor to the economy of the country for centuries (Meenal and Ranjan, 2006).

The silks produced by the silkworms can be classified into two main types of silks namely, Mulberry silk produced by the *Bombyx mori* silkworm and Vanya or non-mulberry silk produced by tasar, muga and eri silkworms belonging to the *Saturniidae* family (Bukhari et al., 2019). The mulberry silkworm feeds only on the leaves of mulberry plants (monophagous) while the non-mulberry silkworm feeds on a numerous host plants (polyphagous). Mulberry is the most famous silk in the world. India holds a special privilege of being the only nation in the world to produce four different types of silks, namely mulberry, tasar, eri, and muga produced by the silkworms *Antheraea mylitta*, *Antheraea proylei, Samia ricini* and *Antheraea assamensis* respectively (Boro and Borah, 2020).

The sericigenous insect fauna of north-eastern India along with their food plants form a separate habitat called "Seri-biodiversity" (Chakravorty, 2004). Production of mulberry silk is a significant industry in India, with the country being the second largest producer after China. The major states producing mulberry silk in India are Karnataka, Tamil Nadu, West Bengal, Andhra Pradesh and Jammu Kashmir (Dasari and Venkataramana, 2023). The North-eastern region of India is also rich in diversity of sericigenous insects and it also contributes a major part to the total silk production of the country where all four types of silk i.e., Muga (*A. assamensis*), Eri (*S. ricini*), Oak tasar (*A. proylei*) and Mulberry (*B. mori*) silkworm have been commercially exploited for silk production (Boro and Borah, 2020). Among all the silks, eri silk is becoming more popular in recent years as it is the only silkworm which is domesticated among the non-mulberry silkworm species and reared completely indoors. Ericulture is chiefly confined to North-Eastern region of India. Reports also indicated that states of Assam, Nagaland, Meghalaya and Manipur account for nearly 90% of eri silk produced in the country (Chowdhury, 1982). The areas bordering Assam and Meghalaya are considered to be the home for *S. ricini* however, it is also practiced in the states of Bihar, Orissa, West Bengal and Andhra

Pradesh on a smaller scale (Rao, 2003). It is a multivoltine, domesticated non mulberry silkworm which is commercially exploited for its silk and by-products since time immemorial. Although it is unclear how eri culture actually originated in Northeast India, Assam has always been the native home of the eri silkworm (Jolly et al., 1979).

A total of 19 species of eri silk moth have been recorded in tropical Asia (Peigler and Naumann, 2002; 2003), with three species of eri silkworm, *S. ricini, S. canningi*, and *S. fulva* being exclusive in India (Peigler and Naumann, 2002). The domesticated *S. ricini* and its wild progenitor *S. canningi* is the inhabitant of North East region of India. Aside from them, *S. fulva* has been reported from the evergreen lowland forests of the Andaman Islands (Mohanraj et al., 1998). The domesticated species of eri silkworm is *S. ricini*. The genital structure, wing pattern, and chromosome number indicates that it is descended from *S. canningi* (Peigler and Naumann, 2003).The taxonomic classification of *S. ricini* is given in below

Phylum: Arthropoda
Subphylum: Hexapoda
Class: Insecta
Order: Lepidoptera
Superfamily: Bombycoidea
Family: Saturniidae
Genus: *Samia*
Species: *S. ricini*

Figure 1: Taxonomic classification of eri silkworm, *Samia ricini* (Donovan).

S. ricini is the only *Saturniidae* species reared entirely indoors among non-mulberry silk moths and the multivoltine cultivated species of eri silkworm (Peigler and Naumann, 2003). This cultivated species thrives in the warm and humid climate of North East India. Eri silkworm can be raised all year in temperatures ranging from 25 to 30°C and relative humidity levels ranging from 75 to 80%. It is divided into six homozygous strains based on larval colour and body markings: Yellow plain (YP), Yellow spotted (YS), Yellow Zebra (YZ), Greenish blue plain (GBP), Greenish blue spotted (GBS), Greenish blue zebra (GBZ) (Sarmah et al., 2002). These strains produce a variety of appealing coloured cocoons, including white, creamish white, deep brick red, and light brick red. The Kokrajhar Eco race of *S. ricini* produces brick red cocoons. The cocoon colour is however temporary that goes away on boiling (Chattopadhyay et al., 2016).

S. ricini is more disease tolerant than its wild progenitor and can withstand crowding and indoor rearing. Ericulture has attracted mostly the rural people of the country and it is practised as a part-time occupation by the women along with the household chores (Gupta and Gupta, 1987). According to Thangavelu (1989), the eri silkworm is more disease resistant and tolerant of humidity and temperature fluctuations. Prasad and Sahu (1992) also stated that the eri silkworm can withstand adverse environmental conditions. Adults do not fly like their wild ancestors, and their cocoons contain more silk and lack peduncles.

Ericulture is less profitable than other silk varieties since it cannot be reeled, but it is nevertheless raised by landless, socially and economically backward farmers in the society. Eri silk's high subsistence value, shine, and luxury promise to boost the rural economy and alleviate poverty (Ray et al., 2018). Eri silkworm requires lesser care as compared to other silkworms. Eri has been regarded as 'ahimsa silk' since there is no need to kill the pupae in order to obtain its silk. Since eri silkworm is domesticated and rearing is done mostly indoors, most of the activities like feeding, rearing and weaving are done by the women (Birari et al., 2019a). The multivoltine eri silkworm*, S. ricini* has five to six generations per year (Derara et al., 2020)

The silkworm is polyphagous in habit and feeds on various leaves of the Euphorbiaceae, Araliaceae, Apocynaceae, and Simarubiaceae families of plants (Chowdhury, 1982; Devaiah and Dayasankar, 1982; Sahay et al., 1997). Although the eri silkworm is known to feed on more than 30 host plant species (Ghosh, 1949; Fukuda et al., 1961), Castor (*Ricinus communis*) is the most preferred food plant for eri silkworm rearing. However, the secondary host plants like Tapioca (*Manihot esculenta*) and Kesseru (*Heteropanax fragrans*) are also utilized by the farmers. The other host plants like Borkesseru or Maharukh (*Ailanthus excels*) and Payam (*Evodia fraxinifolia*) were observed to be the only food plants used for rearing during the scarcity of the primary host plants even though there are numerous other secondary host plants that is locally available (Borah et al., 2021).

The polyphagous nature of eri silkworm makes it easier for the farmers to carry out ericulture since there is an option to use the available secondary host plants in scarcity of the primary host plant. The nutritional background of the larval stage has a significant impact on the larval, pupal, adult, and fibre status (Fukuda et al., 1963; Takano and Arai, 1978; Aftab et al., 1999; Rahmathulla et al., 2002). Castor (*R. communis*) is the primary host plant of the eri silkworm *S. ricini*, according to Lefroy and Ghosh (1912). The remaining host plants, which number in the hundreds, are classified as secondary food plants. In Kokrajhar and most of the north-eastern states, there is no regular plantation of castor plant which is however, often grown to sustain ericulture. The annual nature of the castor plant and the requirement of high maintenance make it expensive for the eri rearers. According to Teotia and Bajpeyi (2009), approximately 90% of Seri-households in the Kokrajhar district of BTC rear silkworms by collecting castor leaves from naturally grown plantations. The castor plant is prone to diseases and the plant also dies during the rainy season due to water logging. Therefore, there is a need to substitute the castor plant by using available secondary host plants for eri culture.

Insects are mostly host specific and they select their preferred host plant in order to obtain the maximum benefit out of the host plants even though most of them are polyphagous. According to Nangia et al. (2000), food plants play an important role in providing nutrition to the silkworm during rearing and in improving the qualitative and quantitative yield of silk. The major source of energy for eri silkworm is the leaves of food plants which may influence the efficiency of digestion and conversion of food to biomass and finally on the growth and development of the insect (Waldbauer, 1968; Bhattacharya and Pant, 1976). The amount and quality of food consumed by larvae affects a variety of parameters such as growth rate, larval duration, survival rate, and reproductive potential. Food plants play a major role in sericulture as leaves are the only dietary sources converted into silk. The growth, development, and economic characters of silkworms are greatly influenced by food plants and the nutritive contents of foliage (Singh and Das, 2006). Economic parameters such as larval, cocoon, and grainage parameters of silkworms are influenced by the nutritional status of the leaves fed to the silkworms (Krishnaswami et al., 1971).

Various studies have been done to study the corelation between the nutrient composition of the host plants and the nutritional and growth parameters of silkworm. According to Raychaudhury (1974), the quality of leaves affects the growth and development of silkworms as well as the overall production of silk. Both inside and outside of India, the significance of proper nutrition in the growing of mulberry silkworms has long been understood (Krishnaswami et al., 1970). Quantitative assessments of the seasonal variation of foliar nutrients in non-mulberry sericulture have been made in a variety of silkworm host plants, including Tropical tasar (Sinha and Jolly, 1971), Muga (Yadav and Goswami, 1992), Oak tasar (Sinha et al., 1986), and Eri host plants (Pathak, 1988).

Selection of food plants with excellent nutritional content is important for the well-being of silkworms and in getting quality cocoon crops since the quality of the leaf has a direct impact on the well-being, development, and survival of silkworms (Dutta et al., 1997). The selection of nutritive superior plants influences the three major factors: survival rate, silk production in terms of quality and quantity, and fecundity. The survival, rate of food intake, digestion, and assimilation are all significantly impacted by the host plants, and these factors have a direct impact on the growth and development of silkworms. Multiple variables, including as growth rate, larval duration, survivability rate, and reproductive potential, are influenced by the quantity and quality of food consumed by larvae (Das and Das, 2003).

Major nutritional requirement for the growth and development of silkworm larvae are protein, carbohydrate, fats, vitamins, minerals and salts (Sinha and Jolly, 1971). Protein is the key factor within cells that is governed by genes (Poonia, 1985) which is important biological macromolecules that are required for growth and development of the silkworm as well as silk synthesis (Talukdar et al., 2015).

Carbohydrates are yet another important class of biomolecules that serve as an energy source and protect silkworms in adverse conditions. It has been proposed that the silk moth fat body is a primary site of lipid synthesis and storage, which is then released into the haemolymph for further utilisation and transport to the target organ (Downer, 1985). The pathogenic effect on the fat body may also change the lipid content of the haemolymph.

Haemolymph is the only extracellular fluid of insects and serves as a reservoir for the products needed for every physiological activity of the insect body (Pawar and Ramakrishnan, 1977). Consequently, changes in haemolymph composition represent the physiological and biochemical transformations taking place in the insect tissues. There is an enormous amount of variation in chemical makeup of haemolymph even between members of the same breed, let alone across distant breeds at various phases of development (Florkin and Jeuniaux, 1974). During active feeding in the larval stage, the fat body synthesises many proteins released into the haemolymph (Kumar et al., 2008). Haemolymph is perhaps the only extracellular fluid that has diverse role and serves as a reservoir for the products that is required for the overall physiological activity in insects. Therefore, any changes in the biochemistry of haemolymph reflect physiological and biochemical changes taking place in the insect.

The silk fibre is secreted in the silk gland of the silkworm which is a modified labial gland. The silkworm secretes the sericigenous protein during spinning which is passes through the anterior gland and expelled through the spinneret opening present in the mouth of the insect (Shimizu, 2000). Sericin and fibroin are two proteins that work together to form silk fibre, which is made from soluble protein found in haemolymph. Sericin, the amorphous protein is a small component produced in the middle part of the silk gland while fibroin is highly crystalline core component of silk fibre produced from the posterior part of the silk gland (Fedic et al., 2002).

Ericulture is mentioned as an important farming practice for generating income and employment by using silk and its by-products for various purposes. It also gains popularity and importance owing to the fact that the larvae and pupae of *S. ricini* are also exploited for edible purposes. The pupae of eri silkworm are a delicacy for the tribal people and cocoon or silk production is more or less a by-product (Sarmah et al., 2011; Paul and Dey, 2014). Eri pupa is a delicacy and dietary staple for many ethnic tribes in North-East India, including the Rabhas, Bodo, Abor, Miri, Kochari, Garo, Khasi, Naga, Adi, and Mizo (Roychoudhury and Joshi, 1995). It is believed that the pupae is a good source of nutrition however, the literature available on the nutritional content of eri pupae is scanty. The eri pupae are known to contain a good amount of crude protein, lipid and amino acids. However, the literature available on the nutritional content of *S. ricini* is scanty therefore, the present study is undertaken to study the nutritional content such as protein, carbohydrate, amino acid, fatty acid, mineral and antioxidant properties of *S. ricini* as well the effect of host plant on the biochemistry and nutritional content of the silkworm.