CHAPTER- 1

INTRODUCTION

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Silk is a functional term used to define the solidified protein secretions by certain Arthropodan invertebrates such as silkworms, spiders, scorpions, mites, flies etc. that are spun into fibres (Kaplan *et al.*, 1992; 1994; 1998 and Altman *et al*., 2003). These invertebrates use it for a variety of functions, including formation of protective shelters (i.e. cocoons), capturing food (webs), structural support, reproduction, foraging etc. due to its excellent fibre quality i.e. soft, lustrous, smooth, strong and durable than any natural or artificial fibre (Craig, 1997; Lamelu, 1998; Hiwar, 2001 and Craig and Riekel, 2002). However, traditionally, silk fibres are extracted from the cocoons produced by *Bombyx mori* silkworms and to a relatively small extent from the wild silkworms belonging to the *Saturniidae* family.

Silk has played an important role in human civilization and economy ever since its discovery more than 5000 years ago. The importance of silk has not been diminished inspite of the discovery of man-made fibres (Choudhury, 1992). Even today, silk continues to reign supreme as the 'Queen of Textiles'. Although produced in small quantities compared to other textile fibres, it still holds a position of importance among the textile fibres and is universally sought after for its elegance and colors.

Silk is familiar to the human civilization for a long time chiefly as an esteemed textile material. As the silkworms produce silk cocoons, these cocoons have been used as a source of silk for producing exquisite textiles and dress materials. It was the cocoons of *B. mori* silkworm that were used first by the Chinese to produce silk in ancient times. According to Confucius (551 B.C. - 479 B.C.), it was in 2640 B.C. that the Chinese princess Xi Ling Shi was the first to reel a silk cocoon which had dropped accidentally into her cup of tea. From that historic incident, the Chinese discovered and continued the use of silk. The Chinese recognized the value of it and kept that secret very safely from the rest of the world. As a consequence, demand for this mysterious fabric eventually increased and created a lucrative trade route for its export to other Central Asian and European countries known as the 'Silk Road'. Remarkably, for the next 3000 years China successfully run their monopoly of silk production over the world. But finally in the 3rd Century B.C., sericulture (i.e., the cultivation of silkworms) began to find their way into Asia and then to the rest of the world.

Silks produced by silkworms may be classified into two main types- mulberry silk produced by *B. mori* silkworm and non-mulberry silk produced by the silkworms of 'tasar', 'muga', 'eri' etc. belonging to the *Saturniidae* family. The mulberry silkworm is monophagus and it solely feeds on the leaves of mulberry plant (*Morus* spp.) while the non-mulberry silkworms feed on the leaves of various types of plants. Mulberry silk is the most known silk in the world. India has the unique distinction of being the only country in the world bestowed by nature with four varieties of silk namely mulberry, tasar, eri and muga. Production of mulberry silk is mainly confined to the states of Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir. The tasar silk is produced by *Antheraea mylitta* D. and *A. proylei*, the tropical and temperate tasar respectively. Tasar silk is copperish coloured silk and does not possess the luster of mulberry silk. In India, the principal tasar producing states are Bihar, Orissa, Madhya Pradesh and West Bengal while on a small scale tasar culture is practiced in Maharastra and Uttar Pradesh. The major states of eri silk production are Assam, Bihar, Meghalaya and Manipur while on a small scale it is also produced in Arunachal Pradesh, Mizoram, Tripura, Nagaland and Orissa. The golden yellow muga silk is produced by the silkworm, *A. assamensis* and its culture is exclusive prerogative to Assam and adjoining hills (Shetty and Samson, 1998).

NE region of India is one of the ten bio-geographic regions of India harboring varied flora and fauna (Suryanarayana *et al*., 2003). Assam is standing on the foothills of the great sub-Himalayan terrain having numerous waterways, hills and forests. The climate is sub-tropical with four distinct seasons viz., Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December-February). The most congenial atmosphere has made the region the natural home of many varieties of insects, moths and butterflies and particularly some sericigenous insect viz., mulberry, eri, muga and tasar silkworm as well as their corresponding host plants. The eri silkworm has become an inseparable part of Assamese culture and tradition from the days of ancient kings and is closely related to the socio-economic life of Assam.

The advent of eri culture in NE India is lost in antiquity, but the fact remains that Assam was the original homeland of eri silkworm from time immemorial (Jolly *et al.*, 1979). The eri silkworm, *Samia Cynthia ricini* Boisd. is multivoltine in nature having five to six generation in a year (Shaarawy *et al.*, 1975). The silkworm is polyphagous and feeds on leaves of various plants mainly belonging to the family Euphorbiaceae, Araliaceae, Apocynaceae and Simarubiaceae (Chowdhury, 1982; Devaiah and Dayasankar, 1982 and Sahay *et al.*, 1997). Although, eri silkworm is known to feed on more than 30 host plant species (Arora and Gupta, 1979), castor (*Ricinus communis*) is the most preferred food plant for rearing of eri silkworm (Ghosh, 1949 and Fukuda *et al.*, 1961). Kesseru (*Heteropanax fragrance)* is utilized next in this region. The other secondary food plants such as tapioca (*Manihot utilissima)*, Borpat (*Ailanthus grandis*), Borkesseru (*A. excelsa*), Korha (*Sapium eugenifolium),* payam *(Evodia flaxinifloia)*, Gulanch *(Plumeria acutifolia)* etc. are utilized during periods of shortage of main food plants (Fukuda *et al.*, 1961; Sengupta *et al.,* 1974; Choudhury, 1982; Singh and Das, 2006; Chakravorty and Neog, 2006 and Das *et al.,* 2006). Eri silkworm produces cocoons of white or creamy colour. However, the Kokrajhar ecorace of eri silkworm produces brick red cocoons. But the colour is temporary and goes away on boiling. All eri cocoons lack peduncle.

Almost all insects are host specific and selects their most preferred food in order to extract the maximum benefit out of it, although most of them eat a great many varieties (Brues, 1946). Different food plants may influence differently on food intake, efficiency of digestion and conversion of food to body biomass and finally on growth and development of insect (Waldbauer, 1968 and Bhattacharya and pant, 1976). Scriber and Slansky (1981) and Slansky and Scriber (1985) critically reviewed these aspects of nutrition ecology of insect and concluded that nutritional indices as well as growth and development of insect varied on different host plants. Food plants play a major role in sericulture because the leaves are the only dietary sources converted into silk of high commercial values. Protein metabolism is important in the silkworm because of its vital role in the determination of chemical characteristics of silk proteins (Shigematsu, 1960). Nutritional background of the larval stage significantly influences the status of the resulting larva, pupae, adult and fibre (Fukuda *et al*., 1963; Takano and Arai, 1978; Aftab Ahmed *et al*., 1998 and Rahmathulla *et al*., 2002). The three major factors, viz., survival rate, silk production in terms of quality and quantity and fecundity depends on the selection of nutritive superior plants.

Various studies have been made to find out the relationship among the nutritional and economical characters of silkworm and nutrient constituents of host leaves. Fukuda (1960) worked out the correlation between the mulberry leaves taken by the silkworm, *B. mori*, the silk protein in the silk gland and the silk filament. Fukuda *et al.* (1963) further worked out the correlation between the leaves consumed by the silkworm larvae in different ages of the larval growth and production of cocoon fibre spun by the silk moth using C_{14} labelled mulberry leaves and stressed the importance of ingestion during fifth instar larval development in relation to silk production. Sastri (1962) observed that accumulation of protein in larvae depends largely on the concentration of carbohydrate in the leaves. Ueda and Suzuki (1967) revealed that the amount of food ingested increases more rapidly than digested and the digestion ratio becomes lower in proportion to the increase in accumulative amount of food digested. Yamamoto and Gamo (1976) observed a significant positive correlation between ingesta and cocoon weight, shell weight and larval weight in silkworm, *B. mori*, while Tamamoto and Fujimaki (1982) encountered negative correlation between cocoon shell weight and ingested dry matter for production of a unit cocoon shell weight. The relationship of amount of food intake and cocoon productivity was also studied by Takano and Arai (1978). Shamachary *et al.* (1980) reported that ratios of cocoon weight, pupal weight and shell weight were dependent on the weight of full grown larvae. Smioka *et al.* (1982) studied the relationship among food ingestion, food digestion and body weight gain in silkworm, *B. mori* larvae under restricted feeding by the indices and revealed that smaller feed index increased the level of efficiency of conversion of ingested and conversion of digested food to body biomass. Li and Sano (1984) observed that high quality of carbohydrates and lower levels of water and proteins in the feed resulted in slower larval growth, less body weight and cocoon weight. Joshi (1985a) observed that food consumption had positive relationship with fecundity. Maximum food consumption of castor resulted in maximum fecundity while less consumption of food on tapioca resulted in less fecundity in moths. Singh and Prasad (1987) observed that there was significant and positive correlation between different pairs of characters viz. body weight, and potential fecundity, pupal weight and fecundity, pupal weight and potential fecundity and body weight and longevity. They also observed that the adults whose larvae fed on three local cultivar of castor, viz. white, pink and red, laid comparatively more eggs. Nagalakshamma *et al.* (1988) found highly significant association of cocoon weight with pupal weight and shell weight in eri silkworm. Paul *et al.* (1992) found a high degree of correlation between larval weight and leaf moisture content. Jayaramaiah and Sanappa (1998b) revealed that in eri silkworm the larval duration, weight, survivability and effective rate of rearing (ERR) have significant positive relationship with moisture, total carbohydrates, total amino acids, phosphorus, potassium, calcium and magnesium content of castor leaves.

Silk fibres are paracrystalline in nature and finds extensive use in textile industry. A silk filament is a continuous thread measuring several hundreds of metres in length. Compared to cellulose and other synthetic polymers, silk is peculiar for its durability, high strength, luster and other unique features (Reddy and Yang, 2010). These excellent physical properties have made silk sought after for use in high-fashion clothes and other decorative items.

The silk fibre is synthesized in the silk glands of the silkworm, which are modified paired labial glands. When the silkworm secretes the liquid silk during spinning, it is passed through the anterior gland and expelled out through the spinneret opening situated at the mouth of the insect (Shimizu, 2000). Silk fibre consists of two types of proteins, *fibroin* and *sericin*. The fibroin is the highly crystalline core component of silk fibre produced from the posterior section of the silk gland. The principally amorphous protein, sericin is a minor component produced in the middle section of the silk-gland (Sehnal and Akai, 1990 and Fedic *et al*., 2002) that serves as a glue-like coating on the two fibroin cores.

The quality of the silk fibres can easily be measured with the tensile properties it possess. The tensile properties are the most important mechanical properties of fibres which include their behavior under forces and deformations applied along the fibre axis. The tensile properties include breaking strain, breaking tenacity, Young's modulus and toughness (Booth, 1996).

Earlier reports indicate that the Brahmaputra valley of Assam and its adjoining States of the NE region together produce more than 90% of eri cocoon, while the rest is produced elsewhere (Choudhury, 1982). Assam is also one of the biggest producers of eri silk.

The byproducts of ericulture are also useful in a variety of ways. The unused leaves and branches produced from pruning are utilized as cattle feed, fuel and manure. The stem of castor can be used in paper industry. The castor seeds which contain about 45% of nitrogen in the oil cake can be used as manure or antidote to white ants in the fields. The litter of eri silkworm can be used as component in production of vermicompost. The eri pupae contain 60% crude protein, 25% lipid and 5%-8% free amino acids and it is a delicacy among many tribes of NE India. The pupae oil is used in preparation of emulsion solution in the jute industry to make jute fibre soft for easy spinning.

Traditionally eri silk is known for simple living and used only in manufacture of gents' chaddars and ladies shawls, that too in natural colour. Besides the traditional shawls we can see diversified and specialized items viz. ladies garments like chaddars, dokhanas, skirts, children garments, kurtas, jackets, cross stitch and embroidery work, fashion accessories like ties, scarves, stoles, kerchiefs, bags, wallets, file, folders, etc. that were not available earlier. Eri crepes using extra twist in both warp and weft and increasing the shrinkage so that it could well be used for modern dresses like ladies skirts etc. by blending it with other silks and natural fibres like cotton wool and polyester for both durability and decoration (Siddiqui *et al.*, 1993). The eri silk is warm, strong, durable and resistant to sunlight as well as acid and alkali (Choudhury, 1981).

Sericulture is an agro-based rural industry of rearing of silkworms, the end product of which is silk (Sastry *et al*., 1987). It provides employment at various levels i.e., host plant cultivation, silkworm rearing, reeling, spinning, weaving and marketing of silk and other by-products. In India, sericulture is one of the important sectors of economy as it plays significant role in programs of poverty alleviation. Out of all the non-mulberry silkworm species only eri silkworm is completely domesticated and reared indoor. Ericulture is relatively a less remunerative occupation as compared to the production of other silks, but has its own advantages. Mostly the tribals, landless labours and other socially and economically backward classes of the society are carrying out ericulture.

The reason for under exploitation lies in the eri cocoons being open mouthed and the filament being discontinuous hence is fit for only spinning. Due to non-reelable nature, eri silk gets fewer prices compared to other reelable silks. However, because of high subsistence value of eri silk it holds out the promise of alleviating poverty and supporting rural economy of the grass root level (Patil and Savanurmath, 1994). In spite of the low price fetched by eri silk, eri-culture is more widely practiced than any other silk culture in the NE India and the total eri raw silk production is approximately twice the quantity of all other silk put together (Khanikar, 2001). Sericulture provides whole time or part time employment to people in the rural areas of the country. It is one of the important components of family system for subsidiary income, which requires less investment, gives good and quick return and provides employment opportunities (Benchamin and Jolly, 1986).

Eri silkworms require comparatively minimum care than other silkworms. Eri silk has always been identified as ‘Ahimsa silk’ because there is no need to kill the pupae for getting silk. The fibre is usually spun and woven by the growers. All operations from rearing to weaving are done mostly by women folk. Thus, ericulture has attracted maximum attention of the rural people of India and it is practiced as spare time occupation by the women folk (Gupta and Gupta, 1987 and Batish and Naurial, 2003). For the tribals, eri pupae are delicacy and the cocoon is more or less a byproduct (Sarmah, 2011, Paul and Dey, 2011; Doley and Kalita, 2011 and Chowdhury *et al*., 2015). Ericulture is an excellent example of a subsistence economy where the rearer is the producer, the processor and also the buyers (Choudhury, 1992).

Looking like cotton, soft as silk and having texture of wool, eri silk is known as 'poor man's silk' and more popular is Assam. Ericulture is carried out traditionally during villager's leisure hours from stray castor plantations supplemented occasionally by other secondary host plants in case of shortage of leaves. Eri spinning and weaving are done by villagers in the spare time and required fabrics are woven for the families' consumption. As such, it is not an organized commercial activity like the culture of mulberry silkworm. For the tribals, the eri pupa is a delicacy and cocoon is a by-product. Since eri cocoons cannot be reeled, its yarn do not fetch a good price and it remained as a subsidiary household practice for the tribals in hills and plains of NE India. Incentives have been provided with a view to extending eri culture to the rural areas of hills and plains. Cocoon cooperatives have been established for purchase and supply of cocoons to needy rearers and to the Spun Silk Mill. Marketing facilities have also been provided for finished yarn and fabric. With the improvement of cultural practices and organizational methods, there is a scope for expanding eri culture in the region (Chowdhury, 1982). Debaraj *et al*. (2002) opined that improvement in cultural practice and organizational method has a scope for expanding ericulture.

The sector provides more employment all-round the year as compared to agricultural crops and fetches more income for rural and economically backward communities. Besides being environmental friendly farm activity such as raising of perennial food plants, it also allows commercialization and diversification of farm enterprises. The sector is also considered as cottage industry par excellence by virtue of its agricultural base, industrial super structure and labour-intensive activities. It is remarkable for its low investment and quick and high returns which make it an ideal industry or enterprise and fits well into the socio-economic fabric of India.

With a vision to address some of the problems, a study of nutritional impact on the growth and silk production of eri by feeding on different food plants in different season is realized. Specially, tapioca is generally grown in Kokrajhar District, BTAD, Assam for high demand of the tubers as a food for human consumption. As such, the leaves of tapioca plants can readily be used for rearing of eri silkworms without effecting the growth of the plant. This may attract more rural people to go for ericulture as a subsidiary or main income source.

With these views in mind the following objectives were undertaken in this study.

1. **To ascertain the nutritional parameters of the castor and tapioca leaves.**
2. **To ascertain quality of eri cocoon and silk yarn in respect of castor and tapioca as food plant.**
3. **To evaluate of the role of ericulture in the socio-economic development of the Bodo people in Kokrajhar District.**