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The Utilization of Sericulture Waste for the Improvement of Socio-Economic Welfare in India

D. Bharathi

Department of Biosciences & Sericulture, Sri Padmavati Mahila Visvavidyalayam (Women's University), Tirupati, A.P, India

Abstract: ***Sericulture is an agro-based industry in a developing country like India, where there are lot of resources and labor. The industry is advantageous for the benefit of poor people in providing opportunities for the improvement of the rural livelihood. Sericulture has played a major role in the socio economic life since 4000 years especially in occasions like marriages. Sericulture involves large scale of interdependent technologies from which useful by products will be evolved. Through the by- products and sericulture waste products, are used in pharmaceutical, cosmetic, paper, agriculture and food industries. In addition to the production of silk, the industry can produce a number of by products from mulberry and silkworm. The conversion of sericulture waste into nutrient rich vermin-compost by using the earthworms which can be recycled into organic manure is effective for soil fertility and crop production. The handicrafts are prepared by using the waste cocoons and silk having commercial value and also used in several occasions. The waste and the by-products of mulberry and Sericulture enhances the profit and sustainability of sericulture farmers and the industry in India.***

Keywords: Mulberry, Sericulture, Industry, By-Products& Handicrafts

1. Introduction

Sericulture is an ancient industry in our country India, dating back to at least second century BC (Jadhav*et al*., 2011). India is developing as leading silk producing country among many silk producing countries of the world. However, global silk industry, which had been focusing on silk production only, previously switched its market for supplying valuable supplements and raw materials for medicine. The importance of silk in Indian economy is evident by the fact that 18 percent of the global raw silk is produced in India. In the textile sector, sericulture is the second largest employer of the country next only to handloom industry and provides employment to more than 50 lakh people.

Mulberry plant possesses medicinal property as it contains some complex chemical substances as in other medicinal plants, in its different parts viz., leaf, root, fruit and the bark (Bose, 1987). Alkaloids and alkali extracts of mulberry stem are active against gram positive bacteria and yeasts (Mishra and Dash, 1992). A decoction of leaves is used as gargle to slow throat inflammation, against diabetes as the leaf extract causes a drop in blood sugar and a reduction in arterial pressure (Tewary and Rao, 1990). The mulberry leaves also act as stimulant for lactation in the cattle (Singhal*et al*., 2001). The entire root is used in blood circulation medication. Mulberry shoots are used as a source of fuel and for paper making, fruits for jam,juice and wine preparation.

Direct application of fresh litter to the field is less effective and often causes spread of silkworm diseases while rearing. Hence it is recommended to use it as compost or obtain manure from livestock fed with litter, in case it is applied for mulberry(Mishra and Dash, 1992).In Japan, tea is prepared from the powder of mulberry leaves, which is consumed by some people as a traditional healthy diet (Nomura, 1988). Tsushida*et al*.,1987 and Machii 1990 have measured gammaaminobutyric acid (GABA) in tea and mulberry leaves and have developed "gabaron-tea" using N2 gas. This "gabaron tea" has property to control high blood pressure (Omori *et al*., 1987). Dried twigs can also be used in composting (Mishra and Dash, 1992). The wood is valued for the manufacture of sports goods like hockey sticks, tennis rackets, badminton rackets, cricket stumps, etc. Mulberry wood contain tannin (0.32%) which can be used in colour and leather industry (Tewary and Rao, 1990).

The importance of various stages of the silkworm, *Bombyxmori* viz., eggs, larvae, pupae, moths and its products, byproducts and waste products used as a potential medicinal source has been reported by Singh and Jayasomu in 2002. In sericulture, apart from silk, there are many other byproducts and waste products obtained at different stages of silkworm rearing. Eggs, larvae, pupae and faeces find their use in pharmaceuticals, cosmetics and the paper and leather industry (Anon., 1996). In China, sericulture products are exploited considerably. Silk is made up of mainly two proteins, fibroin and sericin. Fibroin is secreted in the posterior part of the silk gland while sericin is from the middle part (Qader&Haque, 1996).

The silkworm eggs are also used extensively in transgenic studies (Joy & Gopinathan, 1994). Processed larvae are used in special diets for cardiac and diabetic patients because of their low cholesterol content (Ramakanth& Raman, 1997). The silkworm larvae can serve as a bioreactor for the production of low cost vaccines against various infectious diseases (Datta, 1994). Processed larva of B. mori infected with the fungus Beauveriabassiana (Bals.-Criv.) Vuill. (anamorphicHypocreales, Ascomycota) is one of the constituents of various Chinese decoctions used for the treatment of bronchial asthma, facial palsy and pain, primary trigeminal neuralgia, vocal nodules and vocal polyps (De-zi, 1991; Sen, 1991; Xue-ping *et al*., 1991; Chang-xiong*et al*., 1993). Silkworm larvae are freeze-dried at £ -30 °C, made into a powder/film and incorporated into health food. The larvae have also been found to contain D66b and e-human carcinoembryonic antigen proteins (Song & Wang, 1994; Yamanaka *et al*., 1996).

Silkworm pupae are used as food and as a source of oil for medicines (Anon., 1996). The pupae contain vitamin B1, B2 and vitamin E. Important chemicals, such as chitin and triacontanol have also isolated from the exuviae (Majumder, 1997). Live pupae are used as a medium to synthesize antibacterial peptides in vivo (Koul *et al*., 1994). Pupal oil is used to treat liver and blood diseases (Koul et al., 1994). Silkworm cocoons when hydrolyzed in HCl give composite amino acids (>75.64%) having medicinal applications with low toxicity (Xiong *et al*., 1988b). A therapeutic tar is obtained from the pupae. The bactericidal and antihistaminic activities of the tar are superior to those from plant sources (Kanebo Ltd., 1981). Adult moths are used in making wine and medicines. Male moths are used in Chinese medicine to treat sterility (Rajiv &Vijayakumar, 1996; Raju, 1996; Anonymous., 1996).

Silkworm litter as cattle feed and excreta for bio-gas production and also used as organic manure. Pupae for extraction of oil, amino acids and vitamins and as a poultry and fish feed and used as manure. The silk worm moths are used in the preparation of poultry feed and to prepare medicine for sterility. Kalimuthu and Rajasekaran (1992) studied the possible utility of silkworm litter as an alternative and also supplemented with cow dung and old slurry for biogas production. When silkworm litter is used for bio-gas production, the fermentation proceeds rather rapidly (Shivappa Shetty *et al*., 1978) and also maximum quantity of gas produced when silkworm litter was mixed with other organic wastes (Rajasekaran and Oblisami. 1981).

Refined protein of silkworm pupae is superior to that of fish meal. Silkworm pupae being rich in protein, fat and vitamins,the de-oiled pupae can be used as fish and poultry feed (Mathur*et al*., 1998). The pupal powder can also be used as a moulding material in backelite industry (Bose and Majumder, 1990). The protein rich oil free pupal powder is utilized in preparing dog biscuits (Majhi*et al*., (1991). Based on the process in which waste is generated in silk industry, silk waste is categorized into two major categories, viz., cocoon waste (floss, Double cocoons, pierced cocoons, stained cocoons etc.), and thread waste (rem-reeling waste and twisted waste). The silk wastes form the raw material for hand spinning and mill spinning sector for production of spun silk yarns and the waste can easily be recycled into good organic manure through composting (Naik*et al*., 1992,Singhal*et al*., 2001,). Silk is used in skin lotions, beauty skin creams, moisturizing creams, baby creams and tooth paste (Nazim*et al*., 2017).

By- products of sericulture industry:
(www.indiastudychannel.com/.../126030-Useful-byproducts-of-the-Silk-Industry.aspx.; www.preservearticles.com/…/which-are-the-byproducts-of-sericulture.html).

Various usefulby-products that emerge from the silk industry are

1) The stem in the trees is white in colour, soft and pliable. It is in great demand in the manufacture of sports goods specially cricket bats. Many agricultural implements can also be fashioned out of the stem. Excess of pruned branches can be used as a fuel and the wood pulp of the stem is a good raw material for the manufacture of paper.
2) The remaining of mulberry leaves after feeding silkworms, are given to milch cows. This increase the milk yield hence popularly saying "silk and milk," which reveals the complementary relationship between sericulture and livestock.
3) The waste cocoons are used for the manufacture of garlands, greeting cards, bouquets etc.
4) Mulberry fruits are edible and can also used in the wine industry for making wine.
5) The excreta of silk worms find a number of uses. Silkworm faeces are an excellent organic manure and fish food. Moreover, it enhances the water holding capacity of the soil and destroy harmful pathogen.The faeces of silk worms can be added to the cattle dung to produce gobar gas.
6) The faeces of silkworms are used in the extraction of vitamin E and vitamin K and also in the manufacture of acid resistant plastic sheets etc.
7) Pharmaceutical & perfumery compounds are produced from silkworm litter in China.Silkworm litter used as the healing agent & as medicine for stopping the bleeding of gums.
8) The silkworm pupae are used as delicious food as it contains water, fat protein, glycogen etc. Hence pupae are usedas food in some parts of India and China.
9) Moth oil is used to obtain textile dyes.Oil is extracted from dead pupae,is used in soap industry. After extraction of oil the remaining "cake" is used for poultry feed. Activated carbon and acid resistant plastic sheets are made from faeces of silkworms. This is also used in the production of biogas along with cow dung.
10) Moths are used to prepare pharmaceutical product for curing trauma & to strengthen the masculine function.
11) The liquid extract from the moth can be used to treat impotence, abnormal menstruation & menopausal symptoms.

Bioconversion of sericulture waste products

Silkworm feces act as a raw material for variety of products and also used in the pharmaceutical and food industries (Raju, 1996). The feces have been found to contain solanesol, a highly valued precursor for many cardiac drugs (Babu, 1994). Chlorophyll extracted from the feces of silkworm is used as a medicine for gastric disorders such as ulcer and hepatitis. It is also used to treat liver and blood diseases (Rajiv &Vijaykumar, 1996; Koul*et al*., 1994). Sodium copper chlorophyllin extracted from paste chlorophyll shows antibacterial activity and has medicinal applications. It is used in the treatment of hepatitis, acute pancreatitis, chronic nephritis, stomach disorders and various leukocytopenia. A growth hormone has also been reported from silkworm litter (Majumder, 1997). Pectin from silkworm feces reduces blood triglyceride and blood cholesterol (Raju, 1996). Phytol extracted from silkworm feces is used in the preparation of vitamin E, K, and carotene as a source of vitamin A (Rajiv &Vijaykumar, 1996; Koul*et al*., 1994).

Pelade, the inner layer of the cocoon shell obtained from reeled cocoons is a valuable ingredient of food in China and Japan. Reeled cocoons yield 10% of pelade. It is readily

digestible and reduces cholesterol and blood sugar (Ramakanth& Raman, 1997). Protein and amino acids are also extracted from pelade. Chrysalises separated from pelade, dried and crushed and are incorporated into food for animals (Bedi, 1996; Xiong*et al*., 1988a). It contains palmitic acid, 24.4; stearic, 16.0; oleic, 27.2 and linoleic, 19.9%, and at least 8 amino acids (Lin *et al*., 1983). It serves as food, food additive and also used in pharmaceuticals. Deodorizing methods have also been given to remove any unpleasant odor from the proteins (Zhang *et al*., 1988; Li, 1988; Xiong*et al*., 1988b; Wu *et al*., 1994). Silk film is used for artificial skin, blood vessel and in surgery. As food it reduces blood pressure in human beings (Koul*et al*., 1994). Fibroin extracted from the silk glands of *B. mori* is used for polyacrylamide gel electrophoresis in the presence of sodium dodecyl sulfate (SDS-PAGE) (Yu *et al*., 1996). Sericin in raw silk acts as a silk allergen. It causes contact dermatitis (Inou *et al*., 1997). Floss contains tannins having potential antifungal, antibacterial and antiviral properties (Pandey & Makkar, 1991).

Sericulture waste as compost

Huge quantity of waste (wastes generated during the cooking process, waste generated during reeling process, half reeled cocoon and unreliable cocoons, waste generated in charkha system of reeling, non-twisted silk waste generated during the re-reeling process.) is generated during mulberry cultivation and silkworm rearing, which is a rich source of plant nutrients and can be utilized as alternate to farmyard manure after decomposition. The fungi such as *Pleurotusflorida*and *Pleurotusostreatus* having the ability to degrade woody materials, exploited for hastening decomposition of sericulture waste and recycle the organic matter for producing quality compost to improve the soil health for sustainable sericulture and improve productivity (Naik*et al*.,2012).

Generally in sericulture farms, the left over mulberry leaves from rearing bed and field and other waste including silk worm litter are not properly utilized in preparing compost of high nutritive value (agritech.tnau.ac.in/**sericulture**/seri_**waste**%20product.html). Composting of the waste can be performed quickly i.e. in 50 to 60 days whereas anaerobic composting takes 120 to 150 days. Mulberry branches, as a kind of abundant crop residue, were recycled to synthesize an eco-friendly slow-release urea fertilizer for sustainable agriculture and horticulture applications (According to Zhang *et al*., 2014).

The process of vermicomposting of sericulture waste was carried out by introducing mixed culture of juvenile earth worms Eudriluseuginae, Eiselliafelida and Perionyxexeavalus at the rate of 1.5 kwmt of wastes in each trench (Singhal *et al*.,2000). A good quality vermicompost was prepared from sericulture waste supplemented with FYM. For this purpose fortification was first done to sericulture waste by blending with microbial inoculum like Azotobacter, phosphate solubilizing micro organisms and single super phosphate (Dandin*et al* ., 2000).

Medicinal valueof different parts of mulberry plants:(Nazim*et al*., 2017).

- Special type of tea is made from the leaves which are used to control blood pressure.
- The root bark of mulberry is used in laxative and anthelmintic medicines.
- The fruits juices of mulberry are used to cure mouth ulcers, fever, heart, throat, digestive enhance appetite, control excessive thirst eyesight, anaemia, dizziness, insomnia, hepatitis, constipations, aid in weight loss builds immunity, relieve tiredness and fatigue, increase hair growth etc

The leaf extract of white mulberry (Morusalba) has been studied against the Indian Daboiarusselii venom induced local and systemic effects. The extract completely abolished the in vitro hyaluronolytic and proteolytic activities of the snake venom (Chandrashekara *et al*., 2009). New pharmacological benefits of mulberry leaf against serious diseases like Alzheimer's disease, atherosclerosis, hyperlipidemia etc have been reported. Lyengar in 2007, suggested that mulberry extract provide viable treatment to Alzheimer's disease through inhibition of amyloid beta-peptide (1-42) fibril formation and attenuation of neurotoxicity induced by amyloid beta- peptide. mulberry tea relieves colds, coughs, throat infections, supposed to prevent oxidation of cholesterol consequently keeping the arteries free of fat deposits and hence hardening of arteries.

The fruit drink suppresses the appetite, which is why it has been reported as a useful drink against obesity (Fairjuice, 2008). The mulberry fruits are used for many medicinal purposes such as for balancing internal secretions and enhancing immunity (Venkatesh Kumar and Chauhan, 2008). Mulberry fruits are reported as antidiabetic with antioxidative properties (Kim *et al*., 1998). Hong *et al*., (2004) found that mulberry fruit strengthens the antioxidative defence system and reduces damaging oxidative substances in the erythrocytes of diabetes induced rats.

The mulberry stems are antirheumatic, hypotensive, diuretic etc. Singh and Ghosh, 1992 reported that the stem bark of mulberry is having purgative and vermifuge like properties. A tincture of the bark is used to relieve toothache. Shivkumar*et al*.,1995, reported that root juices of mulberries agglutinates the blood and is very useful in killing the worms in digestive tract.As a source of animal protein and vitamins, the larvae and pupae are economical and abundantly available. The larvae, pupae and their waste and by-products serve good for common urban ailments, such as bronchial asthma, diabetics, gastric disorders such as ulcer and hepatitis, high blood cholesterol, blood pressure, cardiac and other old-age problems. The pupal oil serves good for liver and blood diseases. Diabetes is no more uncommon in India. Pelade, the inner layer of cocoon shell is reported to reduce cholesterol and blood sugar.

Therapeutic applications of silk proteins

Sericin protein is useful because of its special properties such as antioxidant and antibacterial properties, UV resistant, absorbs and releases moisture easily and it also inhibits the activity of tyrosine kinase (Gulrajani, 2005). Pre-

treatment of γ-irradiated silk fibroin in the mouse peritoneal macrophages indicates a higher proliferative effect in a concentration-dependent manner, and this shows the anti-tumour activity of γ-irradiated silk fibroin (Byun *et al*., 2010). The antibacterial properties of silk fibroin (SF) blend films were tested using disc diffusion and turbidity measurement methods against *E. coli* and *Staphylococcus epidermidis* (Basal *et al*.2010). Sericin has very high wound healing property (Wu *et al*., 1996). It has good adhesive property and affinity to keratin (Voegeli *et al*., 1993) Silk threads obtained from silkworm are used for making surgical sutures (Gapurova, 1983). In wounds treated with silk film, there is greater collagen regeneration, less inflammation and less lymphocyte infiltration (Min *et al*., 2004).

Sericin alone or in combination with silk fibroin has been used in skin, hair and nail cosmetics. Sericin when used in the form of cream and ointment has shown increased skin elasticity as well as antiwrinkle and antiaging effects (Henne& Hoppe 1986).Sericin gels when applied on the skin of healthy person have shown a decrease in skin impedance, increase in hydroxyproline level and hydration of epidermal cells. Thus, sericin increases the intrinsic moisture of skin (Padamwar *et al*., 2005).

2. Conclusion

Sericulture industry is having the tremendous uses of various products and by products in preparation of compost, human medicinal use, handicrafts and in cosmetics etc. The silk industry, as an agro-based, provides considerable opportunities to improve rural livelihoods. The silkworm *B. mori*, a potential economic insect whose impact needs proper attention and exploitation for the betterment of mankind. Proper utilization of sericulture and silk waste adds a value of up to 40% to the silk industry.

Sericulture waste upon enrichment can be converted to high value manures and can effectively be used as an useful organic manure in an integrated system for sustaining soil organic status. Silk proteins perform a lot of biological activities, such as antioxidation, and pharmacological functions such as anti-cancer activities, anti-inflammatory and antimicrobial activities. The functional aspects of sericulture will be further developed and finally reborn into a real biotechnology-based sericulture in the future which is bound to add value to industry as a whole. Further investigations are needed to explore the bioactive properties and to improve the need of silk products for socio-economic welfare.

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