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New vistas of value addition in tasar sericulture through utilization of co-products

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Abstract
The tasar sericulture encompasses tasar silkworm host-plant cultivation, rearing of silkworms for production of raw silk, preparation of disease free layings and reeling of cocoons for further processing of silk for weaving. It is multi-fold activity which generates enormous quantity of wastes at each stop. Waste originates at each phase of the activity in various proportion. But, the overall ratio of waste is quite high in tasar sericulture. By utilization and processing of co-product/by-product wastes into valuable products can transfer the sericulture into an efficient functional industry. In order to elevate the productiveness in sericulture there is a requisite for conversion of secondary and waste products into a useful co-product/by-product with its use in various fields. The comprehensive utilization, diversification and value addition is the need of the hour.

Keywords: tasar sericulture, by-product/co-product, food, medicine

Introduction
Man is always inquisitive for silk products. SILK - The Queen of Textiles, spells luxury, elegance, class and comfort. Mankind has always loved this shimmering fibre of unparalleled grandeur from the moment Chinese Empress Shiling Ti discovered it in her tea cup. Sericulture is rearing of silkworms for the production of raw silk. Majorly, the silk is produced by mulberry and non-mulberry or vanya silkworms. Vanya silks arouse the creative passion in designers for innovation, ingenuity and exclusively – naturally and spontaneously. Vanya silks portray the rich crafts, culture and folklore of India. Each of the silk represents its own unique beauty and ethnic culture. Among vanya sericulture tasar sericulture is an occupation practiced by tribal folks inhabiting in the Central as well as North Eastern India for production of silk. Vanya silks are distinguish in looks and feel as they are procured from the wild silkworms that feed on leaves of arjun, asan, sal etc in the open jungles, imbibing the unevenness of nature, and reflecting it in the silks they produce. In unparallel textures, with natural sheen, easy affinity for natural dyes, light in weight and high in moisture absorbency, and with baffling thermal properties like warm in winter and cool in summer, products of rich, salubrious climate and nourishing vegetation.
The silk produced is mainly used in textile industry, on the other hand conversely utilization of huge quantities of co-product/by-products stands an added advantage for elevating the economy of sericulture. The tropical tasar sericulture paves a way for exploitation of by-products in different phases of its activities viz., Host plants, Silkworm rearing, grainage and reeling (Fig. 1). At each stop of activity enormous co-products generated has to be utilized for production of various value added products which has enormous role in the several fields like Medicine/Pharma, Cosmetics, Animal feed, Human consumption, Manure etc (Fig. 1). This paper presents the novel products that can be developed from the wastes at each phase of tasar sericulture activity.

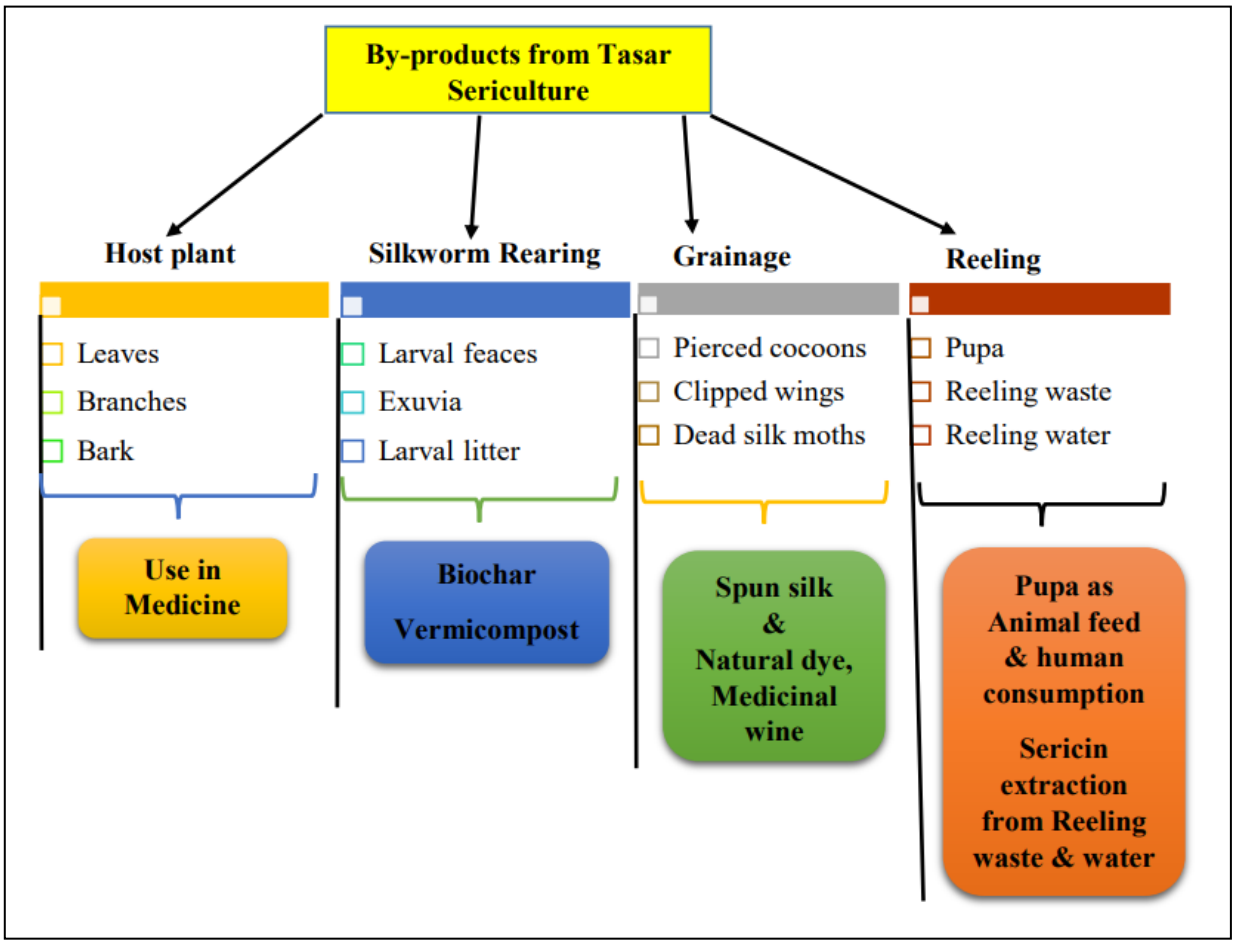

Fig 1: Schematic representation of various by-products generated in Tasar Sericulture

Resources from Tasar Host plants (*Terminalia arjuna and Terminalia Tomentosa*)

Terminalia arjuna is the prime source of food to the tasar silkworm *Antheraea mylitta*. But, arjuna belonging to the Combretaceae family is renowned source of traditional ayurvedic medicine since vedic period which is used to cure many human diseases and to balance all the three humours (Kapha, pitta and vata). It is also found to cure asthma, digestive disorders, scorpion stings and poisonings. The bark of arjuna, asan and chebula found to be used in India for more than 3000 years, primarly as a heart remedy. It was Vagabhatta who, for the first time, advocated the use of stem bark powder in heart ailments. Various extracts of the stem bark of arjuna have revealed to possess several pharmacological properties including inotropic, anti-ischemic, antioxidant, blood pressure lowering, antiplatelet, hypolipidemic, antiatherogenic, and antihypertrophic etc [1]. The major chemical constituents of arjuna viz., triterpinoids, glycosides, flavonoids, tannins, β-sitosterol, steroids (Table 1) etc attract the pharmaceutical industries.

Table 1: Chemical Constituents of *Terminalia arjuna*

SI. No	Part of the plant	Constituents	Chemical constituents
1.	Stem Bark	Triterpinoids	Arjunin, Arjunicacid, Arjunolic acid, arjungenin, terminic acid, ajung IV & V, arjunasides A-E, 2-alpha,3-betadihydroxyrus-12,18-dien-28-O-beta-d-glucopyranosyl ester
		Glycosides	Arjunetin, arjunoside-I, arjunoside II, arjunapthanloside, terminoside, arjunolone, arjunone, baicalein, luteolin, Gallic acid, ethyl gallate, oligomeric proanthocyanidins
		Flavonoids	
		Tannins	Pyrocatechols, punicallin, punicalagin, terchebulin, teflavin C
		β- sitosterol	
		Minerals/trace elements	Calcium, aluminium, magnesium, silica, zinc, copper
2.	Root	Triterpinoids	Arjunic acid, Arjunolic acid, oleanolicc acid, Terminic acid,
		Glycosides	Arjunoside I, II, III, IV, 2α19αdihydroxyrus, 28-oic acid 28-O-β-d-glucopyranoside
3.	Leaves	β- sitosterol Flavonoids Alkaloids Tannins Steriods	

Around the world, the traditional knowledge system has expanded chief importance in perspective with protection, sustainable growth and search for new utilization patterns of plant resources [5]. The left over leaves after silkworm rearing, pruned leaves and branches, stem bark can be utilised in preparation of value products which has a great potentiality in pharmaceutical industry (Fig.2, 3, 4). And also dried leaves may be used as a fodder/forage for cattle and raw material for vermicomposting. The branches and stem of host plant can be exploited in wood and sport industry to manufacture sports items, turnery articles, construction of house, agricultural implements, poles, shafts and bent parts for carriage and carts. The branches and shoots of *T. arjuna* can be utilized to make briquettes, plywood items and also house hold decors. The calorific value and ash content of *T. arjuna* and *T. tomentosa* has to be determined for manufacturing of briquettes in large scale which gives a huge profit as the arjun and asan are available round the year. The small twigs can be used as a source of fuel. The arjuna leaves can be used for preparation of decoction called as arjun tea due to its anti-diabetic and cholesterol reducing properties and also contains a number of health-promoting compounds like alkaloids, carotenoids, carbohydrate, vitamins, fats, minerals, aminoacids, flavonoids, antioxidants etc. The Phenolic compound present in the leaves of arjuna can reduce inflammation, aneurysm symptom and also inhibits the growth of virus and bacteria. The anthocyanins of arjuna leaves possess the potential ability to improve visual acuity. The corporate sectors manufacturing commercial tea may find the possibilities of manufacturing and marketing of arjun tea which may add a new feather to the sericulture industry.

Fig 2: *Terminalia arjuna* plant

Fig 3: *Terminalia arjuna* stem bark

Fig 4: Peeled bark

Usefulness of Tasar Silkworm rearing waste

Abundant waste is generated during tasar silkworm rearing which has got an immense scope for direct or indirect use in agriculture. The major waste generated during rearing includes excess of uneaten leaves, larval litter (60% of ingested food) and exuvia of the moulted larvae. Silkworm excreta or feaces are considered to be a first-rate waste product of sericulture. The silkworm larval litter and exuvia can be utilised as an excellent organic fertilizer as the litter or feaces are very good source of nitrogen, phosphorous and potash. As direct application of fresh litter is less effective hence it may be recommended to convert into compost or vermicompost**.** Few studies opined that the growth hormone can be extracted from silkworm faeces [2]. It is also found to be used for making plastic materials, herbal colorant, natural dyes and also activated carbon of excellent quality. The tasar silkworm litter also forms an ideal raw material for biogas and biochar production. The secondary chemicals present in litter can be used for extraction of chlorophyll, carbohydrates and related compounds and make use of those compounds in medicine or pharma. Silkworm muddle or dregs is a combination of silkworm faeces, sloughs (exuvia) and small branches with leaves (usually used for transforming worms) may be used as a subculture for mushroom cultivation. The silkworm litter can be utilized in pillow making/ pillow filler stuff as it is believed that it is good for insomnia and arthritis. The chlorophyllin compounds and triacontanol can be extracted from the larval litter and can be used as a potent plant growth regulator for agricultural crops.

The silkworm larvae or pupae can be used as a bioreactors in bio-pharming for production of biomolecules, recombinant proteins and also silkworm derived human proteins.

By-products from Grainage operations

Huge quantity of waste is generated during or after the grainage operations especially in tasar silkworm grainage. Clipped wings of female moth, male and female moths, pierced cocoons, cut open cocoons and discarded eggs are the waste products produced from grainage can best catapult into a value added products (Fig.5 & 6). Female and male moth wings possess bright colors, those clipped wings can be processed for extraction of natural dyes and also wings are found to be protinetious in nature may be exploited for various purpose. The dead moths and grainage wastes may be used as compost material. The silk moths discarded after coupling and egg laying are witnessed to brew medicinal wine, preparation of healthy food items, as an animal feed and can also be utilized in compost preparation [4]. The beautiful moths can be preserved, framed and sold as wall plates and as

a décor in hotels, resorts and home. The silkworm eggs containing albumin, fats and sugars has a great scope for value addition. The pierced cocoons apart from its usage as spun silk it is also used in biocrafts like eye-catching greeting cards, wall hangings, flowers, Garlands, bouquets etc.

Fig 5: Tasar silk moths collected after oviposition

Fig 6: Wing clippings of tasar silk moth

Applications of Reeling waste

Silk waste obtained at various stage of processing cocoons into raw silk and the dead pupae are the main by-products of reeling industry (Fig.7). The other silk waste further obtained is in the form of floss, cookers and reelers waste and also basin refuse and lastly the reeling water. In the entire life cycle of the silkworm, the stage in which maximum nutrients and energy stored is the pupa (Fig.7). The biochemical composition of silkworm pupa attracts many researchers and various studies on silkworm pupa witnessed that it is rich in proteins, fats, oil, E, B1, B2 vitamins, calcium, phosphorous, alpha-linolenic acid etc make pupae as extraordinarily valuable edible animal protein resource [3]. The silkworm pupae due to their high fat content, are used as chrysalis oil to obtain cosmetic products (cream, soap, lotion, emulsion). It is also serves as nutritious and delicious human food upon value addition. It also has vital application in the field of bio-medical, pharma, cosmetic and chemical industry and acts as a valuable animal fodder, including in fishery and poultry (Fig.9). The pupal oil is rich in α-linolenic acid (ALA) lowers blood sugar, inhibits thrombus and regulates blood fat and liver lipid storage and also useful in regulating inflammatory mediators and interleukins to protect liver. The pupae is used for cultivation of *Cordyceps militaris.* The *Cordyceps militaris* is used to regulated and toned body, cure dizziness and insomnia, spontaneous perspiration, anemia, especially used to treat low resistance of respiratory tract. The pupal Chitin, one of the components of pupal skin, has unique structures and multidimensional properties and is a linear homopolymer of β-1-4-linked N- acetylglucosamine. The pupal chitin is used in post operational to fasten healing of wounds because of its unique properties viz., antibacterial, anti-fungal, anti-viral, anti-acid, and antiulcer, non-toxic, non-allergenic, totally biocompatible and biodegradable.

The sericin and fibrion processed and produced from reeling water and the reeling waste has wide potential application in the field of cosmetics (Fig.8). The silk proteins are thermo-stable, biocompatible and biodegradable as well as the mechanical strength and versatility to generate varied materials from gels to fibres and sponges of silk proteins attracts to biomedical field. The fibroin protein of silk is used in skin regeneration, tendon, ligament and cartilage regeneration, eye, and nerve and bone regeneration. The sericin has vast applications in cosmetic as well as in medical field. Sericin found to be used in manufacture of anti-wrinkle cream, moisturizer, whitener and anti-UV light cream. It is also used as delivery system in drug and cell delivery. In pharmaceuticals it can be used as anti-coagulase and anti-oxidant and as a regenerative medicine.

Fig 7: Tasar silkworm pupa discarded after reeling silk

Fig 8: Silk reeling waste

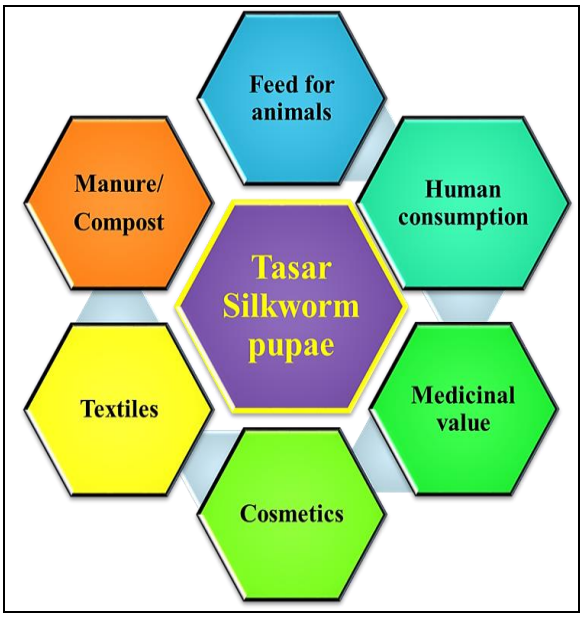

Fig 9: Schematic representation of application of tasar silkworm pupae in various fields

Importance and Scope

The profitability of a commodity increases when a raw material is converted into a unique product. It increases the net cash return of a small scale sericulture enterprise. It also gives high premium to the grower and provides quality products for the domestic as well as export market. Nowadays consumption pattern is getting diversified towards value added products. Value addition in sericulture products through processing, packaging and supply chain management would increase farm income, decrease losses, generate employment and development of national economy.

Conclusion

Tasar sericulture is a magnificent gifts of nature to genius of global designers, to explore and create various value added co-products/by-products as far as creative imagination can stretch. Proper utilization of secondary and waste products of tasar sericulture industry can generate extra income in addition to the silk, the main output. The effective utilization of these waste products for value addition is a must for placing sericulture on sound footing. Value addition has to grow into key words of victory in sericulture trade at global level. If Sericulture has to be economical, we should diversify the produces and the produces should be subjected to new product development as well product diversification for harnessing full advantage from present scenario and development. Besides making tasar sericulture competitive, value addition also helps in avoidance of post losses, industrialization, employment generation, export, extended availability of produce, foreign exchange earnings and product diversification, easy marketing etc. It is therefore, appropriate time for us to come out of primary processing and bulk exporting and get into newer product development and marketing of ready to consume product through value addition.

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