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FOOD AND MEDICINAL VALUES IN "SILKWORM" AND ITS HOST PLANT "MULBERRY"-EXPLORING NEW HORIZONS

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ABSTRACT

Mulberry is the sole source of food material for silkworm, *Bombyx mori* L. In nature, there are innumerable plants that have one or the other medicinal values, beneficial to mankind. As health becomes a great concern of people now a day, many natural ways to take care of one's health are gaining momentum. One of these is having food and beverages made of herbs, and it has been scientifically proved that their values are either equal or better than those made chemically, but have no side effects to our health. In recent years, mulberry green (herbal) tea in the brand name of "Ranowghana" is fast becoming popular in Japan and Thailand as it is believed to prevent high blood pressure and diabetes besides it reduces muscle cramp and body pain, reduces the risk of cancer, increases natural activity of body organs and reduces body weight. In China, providing mulberry leaf juice is the most common hospitality in the villages for a visitor. Mulberry fruit is well known as esteemed dessert fruit. In Greece, it is fermented to derive intoxicating beverage. Mulberry fruit is having high source of vitamin C which is commonly used for the preparation of special wine and beer in most of the cold countries. Ripe mulberry fruit can be made use in the preparation of tasty jelly or syrup. *Morus nigra* Linn or black mulberry is now in the headlines for its omnipotent medicinal properties which may even cure the AIDS. Like mulberry silk worm cocoon pelade, the inner and unreelable layer of cocoon, is being used as a valuable source of nutritious food in china and Japan. It is reported that it is easily digestible and assimilable with the properties of reducing cholesterol, blood sugar level and provides additional energy. This could be used for extraction of free amino acid, which can be utilized in the pharmaceutical, food and fodder industries as cheap source of raw material. In Japan, it is commonly called as 'Shinki fibroin' which is hydrolyzed from the waste silk fibre by enzymes treatment and refined chemically for use in preparation of food items and is consumed with milk or coffee, as it is proteinaceous in nature and effective in overall development of human body. Recently, reports have been published on the wide ranges of biomedical applications such as matrix of wounds dressing and drug delivery system of silk protein. The Chitin from silkworm has got the ability to absorb arsenic from portable water. Silkworm also used as a "bioreactor" for production of low cost vaccine against infectious diseases of human beings. Secretio Peptidase, an enzyme converted from silk gland protein can be used as medicine for curing various diseases. Silkworm larval dry powder can also be used for control of diabetes.

Key Words : *Bombyx mori* L, Ranowghana, Shinki fibroin, jelly, cocoon pelade, unreelable layer of cocoon, proteinaceous, Chitin, assimilable, bioreactor, *Morus nigra* Linn cures AIDS.

INTRODUCTION

Sericulture occupies a unique position in Indian Economy. It is a labour intensive industry combining both agriculture and industry. In its production process sericulture affects a long chain of inter dependent and specialized operations which provide means of livelihood to a larger section of the population mainly in rural and semi urban areas. By cultivating one hectare of mulberry about 13 man years of employment is generated across the chain of activities namely silkworm seed production mulberry garden and silkworm rearing management, cocoon reeling, twisting, weaving, dyeing, printing and by-products processing. Since then the industry is flourishing

despite many ups and downs. The bygone years have faced many challenges like climatic changes, war, natural disasters, drought, industrialization, urbanization, and change in government policies, shortage and increase in cost of labours. Despite of these hiccups, sericulture has definite advantages over other crops because silk is not only used as textile but also in other areas such as pharmaceuticals, cosmetic industry, nutritive products and in medical field to suture wounds so as the case in mulberry too.

The research emphasis on silk has changed from mulberry cultivation, silkworm rearing, reeling, weaving etc. to harnessing the myriad attribute of silk. The image of

shimmering fabrics and dresses is about to change as biopolymer, as bioreactor for drug production, as scaffold to grow heart muscle, bone repair, cartilage, in optics, in electronics, in technological usage, vaccine production, cosmetics, control of diabetes, for drug testing, in space travel etc. That is the reason for the fact that is no let-up in sustained research efforts in Japan, China, but also the increased activity in Europe, Oxford, USA even though the silk output as textile is decreasing. In Korea, production of raw cocoon has almost disappeared, on the contrary, the R&D of health care functional products using silkworm materials has been making considerable progress both fibroin and sericin and mulberry.

FOOD AND MEDICINAL VALUE OF MULBERRY



FOOD VALUE OF MULBERRY

MULBERRY GREEN TEA RANOWG HANA FOR GOOD HEALTH

As health becomes a great concern of people now a day, many natural ways to take care of one's health are gaining more and more popularity. One of these having food and beverages made of herbs, and it has been scientifically proved that their values are either equal or better than those made chemically, but have no side effects to our health.

The mulberry Research Institute of the Department of Agriculture, Thailand has developed mulberry tea as a healthy beverage taking into consideration its positive health values. It is known fact that, for a long time the Japanese have been using Asian mulberry herb tea as a beverage since it is believed that, mulberry green tea prevents high blood pressure and diabetes to a considerable extent. As such in Thailand also many people have now become familiar to mulberry green tea. It is found that, mulberry leaves contains high components of minerals and vitamins essential for human. Fresh mulberry leaves are being used as a normal ingredient in preparation of several dishes by the people of North-eastern part of Thailand. The Ranowg hana tea said to be caffeine free, sugar free and with no toxic contents.

NEW BEVERAGE

Recently, the Thai Department of Agriculture in cooperation with private sector partners has conducted studies on production of tea from mulberry leaves for commercial marketing as a beverages. Mulberry herb or green tea's characteristics have been accepted by the Thai

Industrial Standards Institute considering its odour, colour and flavor compared to standard quality tea beverage. After brewing, mulberry tea gives a unique flavor, which is less tannic, bitter than that of tea processed from tea leaves. It is found that mulberry leaves contain high components of minerals (Ca,K,Na,Mg,Fe & Zn) and vitamins(A₁, B₂, & C) and amino acids with low caffeine percentage of only 0.01%.In China, Providing mulberry leaf juice is the most common hospitality in the villages for a visitor.

PROCEDURE FOR PREPARATION OF MULBERRY TEA

The mulberry leaves (leaving first four tender ones) are plucked and chopped into small pieces (1/3 sq cm) and boiled in hot water to 90° C for 20 to 30 minute. Then the material is spread in a hot pan for about 30 minutes and dried in oven for one hour at 80° C. This is then packed and sold in market for 30 Bhat per kg. Around 5 kgs. Of mulberry leaves are required to prepare one Kg. of mulberry green tea.

MULBERRY FRUIT – AN IDEAL FOOD



Morus alba is generally considered as the one for silkworm feeding and *Morus nigra* for the fruit. some varieties of *Morus rubra* are also grown for their fruits for fruit bearing purposes, trees are planted at a distance of 20 to 40 feet from one another.

Mulberry starts producing fruits in may-June. Fruits are syncarpous formed by the coalescence of a spike of flowers. Each flower produces a fruit that is nutlike and surrounded by fleshy floral parts. The shape and size of fruits vary from variety to variety. Usually they are ovoid or subglobose or ellipsoid to cylindrical. The colour varies from white to pinkish white, purple or dark purple to black. Fruits of some species like *Morus macroura* reach upto a length of 8 cm. this tree is usually grown in the backyard of house in north India for the purpose of its tasty fruit. Mulberry fruit is well known as esteemed dessert fruit.

The fruits of mulberry are sweet and soft. Because of their sweetness they are of little value for culinary uses. The ripe fruits are harvested by gently shaking the tree. Ripe fruits of mulberry are sweet and well flavoured and are eaten fresh or made into jam, jelly or sherbet, syrup. In Europe, a wine is prepared by the fermentation of the fruits. In Greece, it is fermented to derive intoxicating beverage. Mulberry fruit is having high source of vitamin C which is commonly used for the preparation of special wine and beer in most of the cold countries.

PREPARATION OF MULBERRY JELLY

In a medium sized sauce pan, take 450 gm mulberries, one large apple and 125 ml water to boil over moderate heat. Cover the pan, reduce the heat to low and cook the fruit for 20 minutes or until it is soft and pulpy. Remove the pan from the heat. Pour the fruit mixture into jelly bag and leave it to drain. Measure the quantity of juice. For each 600 ml of juice add 450 gm of sugar. Place the pan over moderate heat and stir until the sugar has dissolved. Increase the heat to moderately high and bring the mixture to boil. Boil briskly, without stirring for about 10 minutes, or until the jelly has reached setting point. With a metal spoon, skim the scum off the surface. Ladle the jelly into hot, dry jam jars and cover and store in a cool, dry place.

PREPARATION OF MULBERRY SYRUP

Wash, fresh ripe fruit in cold water and drain. Place the fruit in a basin that will fit over a large sauce pan, or use a double boiler. Depending on the juiciness of the fruit add water. Fill half of the source pan with water and reducing to low heating point reduce to simmering point. Place the bowl on top of the sauce pan on the top of the double boiler over the water and heat the fruit until the juice flow out. Press the fruit with a wooden spoon while it is cooking .make sure that the water in the lower pan is replenished when necessary. When the juice is flowing freely crush it with a potato masher. When all the juice has been extracted, pour it into a jelly bag with a bowl underneath it and allow the juice to drain through for 24 hours. Press the pulp thoroughly to extract the remaining juice. Add about 350 gm sugar to every 600 ml of juice and stir without heating until the sugar dissolves. Strain again through muslin or a fine meshed nylon sieve. Pour into clean dry bottles and cover them.

CHEMICAL CONSTITUENTS OF MULBERRY

The important chemical constituents of mulberry are.

- Water
- Protein (globulin, glutelin, prolamine, albumin, protease, etc) Amino acid components of protein are glycocholl, alanine, leucine, aspartic acid, glutamic acid, phenylalanine, proline, oxyproline, cyctenine, cystine, etc.)
- Non-protein nitrogenous matters are nitrate and ammonia compounds.
- Carbohydrates (glucose, fructose, sucrose, dextrin, starch, galactan, araban and crude fibres).
- Fat
- Ash (Calcium, phosphorous, silicon, manganese, magnesium, iron, copper and zinc, etc.).
- Organic acid and tannic acid (Oxalic acid, Tartaric acid, Citric acid and Malic acid).
- Vitamins –A, B, C and D (Ergosterol).
- Chloroplast pigments: Chlorophyll A (blueish green) and Chlorophyll B (Yellowish green).

MEDICINAL VALUES OF MULBERRY

- Mulberry leaf juice has a special quality of moisturising capacity for the skin and keeps the skin smooth and healthy.
- Mulberry leaf juice also prevents throat infections, irritation and inflammations in the throat.
- Mulberry leaf juice lowers blood sugar level among Diabetic people.
- Mulberry leaf juice reduces hypertension among people having high BP.
- Mulberry leaf juice reduces blood cholesterol and body fat.
- Mulberry leaf juice reduces muscle cramp and body pain.
- Mulberry leaf juice controls effectively heart beating.
- Mulberry leaf juice reduces the risk of liver cancer.
- Mulberry leaf juice increases natural activity of body organs.
- Mulberry leaf juice reduces body weight.
- Mulberry fruit juice is commonly used for preventing high fever as Febrifuge. This is the first treatment normally given to any patient with symptoms of fever during endemic malaria. The fruit may also be used for alike purpose; but should be avoided when there is a tendency to diarrhea.
- The fruit juice of mulberry has the property of preventing diarrhea and cold. However, it should be prevented when the patients have confirmed amaebiasis.
- As the mulberry fruit juice has the capacity of reducing high fever it is used to provide excessive strength for withstanding the effect of high fever.
- Mulberry fruit is principally used in the preparation of syrup which possesses refrigerant and laxative properties for infants. The juice which is refrigerant may be used as drink in febrile diseases.

- Mulberry being a member of moraceae which is specialized for their latex producing capacity, has the property of healing the wounds and injuries. It can be used as dermal ointment.
- The root of black mulberry *Morus nigra* has a special effect on the pancreas and glycogenolysis. Hence, root juice is administered to diabetic patients as decoction which has capacity to reduce blood sugar.
- Mulberry root bark has a bitter taste and somewhat acrid. Its juice helps in killing round worms, tap worms and hook worms in the digestive system.
- Mulberry root juice has the capacity of agglutinating the blood. The medicine prepared from the root is called Glucosidae which can be administered to the patients suffering from high blood pressure.

CAN MULBERRY PROVIDE AN ANSWER TO THE SCOURGE OF THE AIDS

"A guess, a hope which may yet save the mankind".

Morus nigra Linn or black mulberry is a well known species cultivated in Kashmir and some parts of Darjeeling in West Bengal. It is a medium or small sized tree, 6-9 meters in height. Although the species is inferior, so far as the Silkworm nutrition is concerned, the black mulberry is now in the headlines for its omnipotent medicinal properties which may even cure the AIDS.

An alkaloid, deoxyjirimycin (or simply DNJ) has been extracted from the root bark of the black mulberry, *Morus nigra*, which interferes with the synthesis of sugar chains, and is supposed to be the magical drug. The chemical resembles glucose and interferes with sugar synthesis and thus hinders the addition of sugar molecules to the outer coat of the human immunodeficiency virus (as the AIDS virus is known scientifically). It has been observed that the surface glycoprotein of HIV is rich in sugar chain and is involved in the building activity of the virus on and from a cell. Although the alkaloid's (DNJ's) activity at the cellular level is yet to be analysed, it is crystal clear that DNJ inhibits the enzymes glycosidases, responsible for trimming the sugar chains on the human cell and hence makes the attack futile.

FOOD AND MEDICINAL VALUE OF SILKWORM



SILKWORM PUPAE AND NUTRITION

Silk worm Pupae rich in vitamins and other nutrients is, in fact a popular dish in Thailand. This would help contain the malnutrition, common in street children and improve their health. Same as the case of Eri Pupae in North-East India.

SILK WORM PROTEIN AS SOURCE IN THE HUMAN DIET FOR THE CREW

The Silkworm protein has also been compared with the protein of other animals. The non-edible part i.e., silkworm cocoons is also considered as a protein source. The silk could be converted into the edible food stuff for humans. Tests are being conducted for utilizing silkworm as the animal protein for the crew who live in CELIS (Control Ecological Life Support System) Which is also called as Bio regenerative life support system and considered now as the most advanced and complicated closed ecological system in the world. The supplementation of silkworm protein in human diet is a possible new approach to solve the animal protein supply.

SILK IS DEMONSTRATED IN MAKING A FOOD SENSOR

A team from IIT, Kharagpur, has developed a new bio-membrane device using silk fibroin. The researchers found that the silk fibroin film showed "switching" properties and can be used in computer memories.

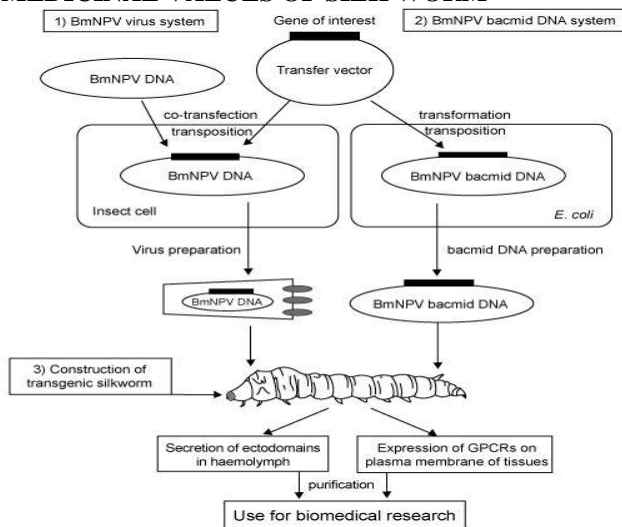
Oxford University group of researchers studying the structure of cocoons say "Silkworms have evolved a remarkable range of optimal structures and properties to protect moth, pupae from many natural threats". These structures are light weight, strong and porous and therefore "ideal for development of bio-inspired composite materials". This could inspire advanced materials for in protective helmets and light-weight armor and even "new

materials for fabricating car panels in some of the fastest growing car markets-China and India”!

PELADE LAYER OF SILKWORM COCOON AS A SOURCE OF NUTRITIOUS FOOD

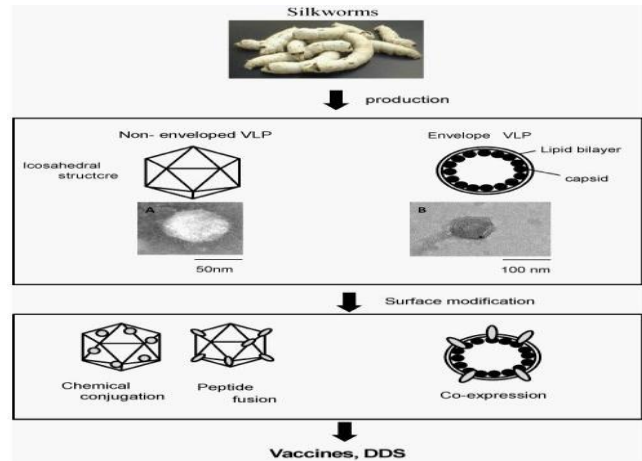
Cocoon pelade, the inner and unreelable layer of cocoon, is being used as a valuable source of nutritious food in China and Japan. It is reported that it is easily digestible and assimilable with the properties of reducing cholesterol, blood sugar level and provides additional energy. In Japan, it is commercially called as “Shinki fibroin” which is hydrolyzed from the waste of silk fibre by enzymes treatment and refined chemically for use in preparation of food items and is consumed with milk or coffee, as it is proteinaceous in nature and effective in overall development of human body.

MEDICINAL VALUES OF SILK WORM



SILKWORMS TO PRODUCE HUMAN VACCINE

It is highly interesting to know that Dr. Smith and his group have already shown that human interleukine (IL) can be produced in large quantity in insects using a polyhydrin promoter. Silkworms infected *in vivo*, with recombinant virus or the silkworm derived BmN cell line infected *in vitro* secreted large amounts of IL-3 into the haemolymph or culture media, as the case may be. On a per volume basis, about 20 fold more activity was found in culture supernatants of the infected BmN cells and 10,000 fold more activity detected in the haemolymph compared to supernatants obtained from mammalian cells transfected with plasmid Pc D-IL-3 using SV40 as early promoter. The purified silkworm produced IL-3 had biological activities indistinguishable from IL-3 produced from mammalian cells as assessed by mast cell proliferation assays using IL-3 and receptor binding assays using IL-3. It is highly interesting to note that silkworm cells glycosylated IL-3 and they recognize the mammalian signal sequence and cleared it at the correct position. (A.Miyajima et al. Gene, 58:273-281, 1987). These observations of Dr. Maeda and Dr. Choudhary will help in developing human vaccines for various tropical diseases, in near future.



SILK WORM *BOMBYX MORI* IS A POTENTIAL TOOL TO USE AS A BIOREACTOR

At present some human therapeutic proteins, such as insulin for diabetics and the clotting factor thrombin are reaped from mammalian cells grown expensive bioreactors. Proteins human plasma is extracted from blood donations. Both techniques are expensive and labourious. Silk worms on the other hand are cheap, quick and easy to rear. The worm could be a boon to biotechnologists looking to scale up recombinant protein production. Silk worm is a easy tool to use it as a bio-reactor for production of enzymes required for medical treatment and also as a effective means to fight diabetes and impotence. Research is also underway in china to use the silkworm to treat cancer and to develop it as a bio-material. Silkworm powder has proved to be a powerful blood glucose-lowering agent, due to the presence of high amount of deoxynojirimycin- a nitrogenous compound, which is more effective than insulin.

SILK WORM DERIVATIVES USED AS INVIGORATOR

Silk worm pupal extract is used for treatment of impotence, which is widely under used and has created great demand in Korea and process is under way to export it to United States, Germany and Japan. The anti-impotence medicinal property of silkworm has a reference to an age-old medicinal record “Dongueibogam” which mentions on the effectiveness of male silkworm in invigorating men’s energy. A fungus called Dongchunghacho has immense medicinal value, which grows on silkworm body. Dongchunghacho live inside the body of host larva in winter. In summer, it kills the host and grows outside the silkworm body in the form of fungus. This fungus has proved to be effective for many purposes including fighting cancer, strengthening immune system and curing fatigue. The other fungus, cordyceps and spaciolomycin are cultured using silkworm pupae which has a high potential medicinal value. Medicines derived from these funguses are reported to be very effective in treating cardiac ailments. Chinese Academy of Sciences and Haining Silk Corporation have succeeded in producing Hepatitis C vaccine in silkworms and in their

cocoons. Approximately 0.5-0.6 mg of the antigen can be administered orally as a liquid or in the form of capsule.

USAGE IN ARTIFICIAL SKIN

Imagine a material that could expand by three to six times in size while remaining strong, stiff, bio-degradable and bio-compatible. Such a material would be of immense value as a wound-healing bandage or possibly a drug-delivery mechanism. Another possibility being explored is that of creating a hybrid silk that would act as an organic surface to which proteins, such as antibodies could be attached without being non-specifically absorbed. Such a surface would be invaluable for protein experimentation and study. The hybrid silk films could be used as bandages to promote wound-healing. A technology has also been developed to produce non-woven natural silk sheet by silkworms. This non-woven silk fabric mimics in appearance, texture and strength of a woven fabric and can be produced as bulky as the thickest padding. It is absorbent, resilient stretchable, soft and washable. Can be used in disposable diapers, sterile wraps and as bio-filters.

USAGE IN TREATMENT OF ARTHRITIS

Serrapeptidase is an enzyme derived from silkworms. It is produced in the intestine of silkworms to break down cocoon walls. Serrapeptidase is an anti-inflammatory proteolytic enzyme. This enzyme is providing to be a superior alternative to the non-steroidal anti-inflammatory agents traditionally used to treat rheumatoid arthritis and osteoarthritis. Its uses have also been extended to the treatment of chronic sinusitis and post-operative inflammation and some researchers believe the substance can play an important role in arterial plaque prevention and removal. Serrapeptidase is used by European physicians for a wide variety of conditions, including: sinusitis, fibrocystic breast disease, post-trauma swelling, arthritis, idiopathic edema, cystitis, epididymitis and post-surgical trauma. Serrapeptidase slices and dices only the dead tissue. It is an extraordinary, inexpensive and entirely safe, food grade natural protein. Its anti-inflammatory effects are superior to other proteolytic enzymes.

PHARMACEUTICAL APPLICATIONS OF SILK FILAMENT

The silkworms, *Bombyx mori* has two silk glands that constitute approximately one quarter of the worm's mass and produce liquid silk. This bio-polymer is composed of a 350 KDa fibroin heavy chain (H-fibroin), a 25 KDa fibroin light chain (L-fibroin) and families bind the two filaments together as they emerge from the glands and harden in contact with the air. The silk thread can attain a length of more than a kilometer.

USAGE IN SURGERY

It is well known that silk thread has been used for many years worldwide for intricate surgical and ophthalmologic operations. Silk is suitable for this purpose because of its fine structure, soft fibres, good tensile strength, easy to tie and difficult to untie. Its protein composition makes it compatible to the human body. In

other medical fields, anti-hay fever masks, gauze pads and bandages for dermatological disorders made from silk have been commercialized in other countries. The development of technology to dissolve silk fibres and make film from silk protein has opened the way for research and development into its use in artificial skin, blood vessels, tendons, ligaments, contact lenses, catheters for surgical procedures and anticoagulants. All these applications exploit silk's bio-compatibility and permeability. Other uses are constantly being explored, such as membranes and filter material, which draw on silk's ability to absorb or filter out specific substances (e.g., oxygen and carbon dioxide) and in bio-sensors using silk enzyme-fixing membranes that trap enzymes. Silk is a natural material and highly bio-degradable, so it promises to play a big role in human health.

USAGE IN COLLAGEN AND THROMBIN PRODUCTION

Silk worm cocoons represent an excellent source of recombinant protein because the silk gland is highly active in protein synthesis. The protein composition of cocoons is simple which facilitates protein purification. Tomita et al.(2003) first reported the stable long-term expression of a human recombinant protein in the silk glands.



Proteins needed in large quantities include collagen and thrombin as well as therapeutics, such as recombinant antibodies or antibody-like molecules that have attained annual market demands of several hundred kilograms. Collagen is used in many medical applications such as tissue engineering because of its strength and compatibility with tissues. Pouring a collagen-based sealant into a wound, could speed up healing and may reduce scarring. The current main source of collagen is extraction from cow skin. Because of the potential risk of transferring viruses between species, an alternative source of collagen is being looked for. Thus, a recombinant collagen would serve as an alternative non-mammalian source for this important therapeutic molecule. Attaining a sufficient supply of some of these drugs, which are produced in mammalian cells at facilities with reactors of

10,000 or more litres, is becoming a major concern for the pharmaceutical industry in general and for bio-tech companies in particular. It is obvious that the protein production capacity of silkworms exceeds that of any other industrial system in use today. In addition, the glands of these insects produce an almost pure product. It is indicated that even with the "low" yields reported, 5 kg of pure collagen can be produce on a surface area of 300 sq.m with five workers caring for 1.5 million silkworms.

CONCLUSION

In conclusion, systems based on *Morus alba* and *Bombyx mori* could become major technologies for the production of high-value proteins, especially in the area of pharmaceutical bulk production. By relaying on Know-how accumulated over thousands of years of mulberry cultivation and rearing of silkworms, the implementation of a low-cost, high yield protein " spinning " production system should be straight forward. The future dream to use silk is to trap carcinogens. To make the happen, one has to undertake in depth studies into the nature of the protein in silk. Further, take silk molecular sequences and mix them with organic material would then expand and contact for drug delivery. The system is expected to go a long way in human medicine. Silk fibroin is a highly promising protein and an object of increasing interest as a potential bio-material for tissue regeneration and repair. The same way mulberry extractions are also very useful for mankind. If properly designed, mulberry and silk may offer new horizons of food and medicine for mankind.

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