

“REVIVING THE MAGIC OF SILK FOR BEAUTY AND HEALTH”

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Abstract

Silk has been intermingled with the life and culture of the mankind. Also known as *The Queen of Textiles*, it 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 teacup. There are four varieties of silk which include-Mulberry, Eri, *Muga*, and *Tasar* which are obtained from different species of silkworms. Conventional uses of silk include apparel and home textiles where it is used to make blouses, dresses, scarves, pants and ties. It can also be made into curtains, draperies, cushion covers and sofa covers. In addition to this, silk is also used in technical textiles where it is used in items like parachutes, bicycle tires, comforter filling and artillery gun powder bags.

Today there has been revival of silk and its products with the customer preferring more environment friendly, natural and skin friendly options. Silk with its inherent qualities of being soft and supple with an abrasion ratio of only 7.4% scores highest in being most human friendly fibre. It has good hygroscopicity and moisture releasability which makes it cool in summers and warm in winters. It is being looked at fabric of beauty and health world over. Silk is also sound absorbing, anti-dust and fire retardant which makes it ideal for use in home textiles as well.

Introduction

Silk withstood many a daunting challenges from other natural and artificial fibres and yet, remained the undisputed Queen of Textiles since centuries. It is one of the world's most enduring symbols of beauty, fulfilling a human love of luxury that no other fabric could satisfy so completely and in so many forms. Traditionally silk was reserved for royalty, but has been a favourite of all lovers of fine quality fabrics.

It is highly valued because it possesses many excellent properties. Not only does it look lustrous and feel luxurious, but it is also lightweight, resilient, and extremely strong-the strongest natural fiber known to man, one filament of silk is stronger than a comparable filament of steel! Although fabric manufacturers have created less costly alternatives to silk, such as nylon and polyester, silk is still in a class by itself. [1]. As described by Farlex's dictionary is "Silk is a fine lustrous fiber composed mainly of fibroin and produced by certain insect larvae to form cocoons, especially the strong, elastic, fibrous secretion of silkworms used to make thread and fabric.[2]

This highly desirable fabric is composed of yarns that are triangular in cross-section, due to which the light dances across the woven fabric giving it that characteristic lustre. It is far stronger than cotton, wool or linen. As with all natural products, variations in silk are an intrinsic characteristic, and some weave and dye lot variations may occur.

However, exquisite qualities like the natural sheen, inherent affinity for dyes and vibrant colours, high absorbance, light weight, resilience and excellent drape etc. have made silk, the irresistible and inevitable companion all over the world.

The Origin of Silk

Chinese legend gives the title Goddess of Silk to Lady Hsi-Ling-Shih, wife of the mythical Yellow Emperor, who was said to have ruled China in about 3000 BC. She is credited with the introduction of silkworm rearing and the invention of the loom. Half a silkworm cocoon unearthed in 1927 Shanxi Province, in northern China, has been dated between 2600 and 2300 BC. Another example is a group of ribbons, threads and woven fragments, dated about 3000 BC, found in Zhejiang province. More recent archeological finds - a small ivory cup carved with a silkworm design and thought to be between 6000 and 7000 years old, and spinning tools, silk thread and fabric fragments from sites along the lower Yangzi River – reveal the origins of sericulture to be even earlier [3].

Manufacturing of silk

Silk is defined as 'yarn reeled from the cocoons spun by the caterpillars of the silk producing insects'. Chemically speaking, silk is made of proteins secreted in the fluid state by a caterpillar, popularly known as 'silkworm'.

It is a protein polymer that is spun into fibers by some Lepidoptera larvae such as silkworms, spiders, scorpions, mites and flies. [6] The core filament is homogeneously distributed polymer blend of mainly two proteins that is coated with glycol-proteins and lipids [7]. The silkworm cocoon silk fibre is composed of two cores of fibroin because their gland is a paired organ which surround by a cementing layer of sericin in a structure known as *bave* (Fig. 1) [8]. The core fibres are encased in a sericin coat, a family of glue-like proteins that hold two fibroin fibres together to form the composite fibres of the cocoon case [9]. This glue-like protein is called sericin which is amorphous in nature and acts as binder to ensure the structural integrity of the cocoon [10].

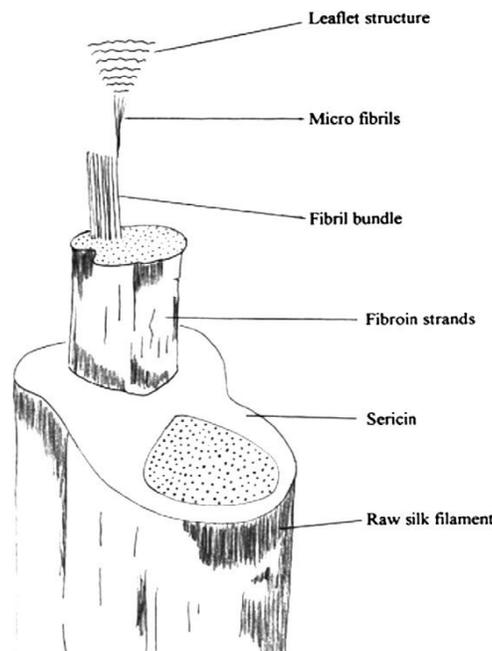


Figure :1 Structure of silk fibre

The fibroin fibre itself is a bundle of several fibrils with a diameter of 1 μm . A fibril contains 15 nm wide microfibrils. Silks are considered semi-crystalline materials with 30–50% crystallinity in spider silks, 62–65% in cocoon silk fibroin from the silkworm *B. mori*, and 50–63% in wild-type silkworm cocoons [11].

Silk worm Life cycle

Silkworms feed on the selected food plants and spin cocoons as a 'protective shell' to perpetuate the life. The domesticated silk worm *Bombyx mori* is reared systematically and its production accounts for almost all raw silk production. However, there are other varieties of wild silkworms as well.

Silkworm has four stages in its life cycle *viz.*, egg, caterpillar, pupa and moth. Man interferes this life cycle at the cocoon stage to obtain the silk, a continuous filament of commercial importance, used in weaving of the dream fabric. A single filament from a cocoon can be as long as 1600 meters. [4] The various stages of the silkworm can be described as:

1. Eggs- The eggs of the silkworm, also known as 'grains' are laid by the *Bombyx mori* moth. The eggs are cold-stored to arrest their development and control the hatching period.
2. Larva or caterpillar- The eggs are prepared for hatching at a temperature of about 22°C (71 - 72°F) to coincide with the appearance the shoots of the mulberry leaves which will feed the newly-hatched larvae. Each egg, the size of a pin-head, produces a tiny caterpillar about 3 mm. long, endowed with a ferocious appetite for mulberry-leaves. After three or four weeks, during which they will shed their skin four times, the caterpillars are fully developed. The caterpillars are now 8-10 centimetres long and weigh 10,000 times as much as when newly hatched. They stop eating and start looking for a place to spin cocoon.
3. Cocoon-In the past; rearing-trays were covered with sprigs of heather or other plants to give the caterpillars a firm support for spinning their cocoons. Nowadays the trays are fitted with flat, bottomless boxes divided into a large number of compartments. The caterpillar begins by stretching a silk thread between the walls of its individual compartment then starts to spin the outer envelope of its cocoon. With rhythmic movements of its head it lays the silk filament in figure-of-eight forms. In this way the caterpillar builds up 20 to 30 concentric layers of thread. Gradually the caterpillar disappears from sight inside its cocoon, which remains porous to allow it to breathe. The caterpillar produces the silk filament thorough a tiny hole in its lower lip called the spinneret, which is connected to the two silk glands running the length of the caterpillar's body. The semi-liquid silk solidifies into a continuous filament on contact with the air. The thread (or bave) is made up of two filaments extruded from each of the silk glands and bonded together after passing through the spinneret. The bave is composed of the two main ingredients: fibroin (75 - 80% of the weight) and sericin (25 - 20%). (Fig: 2) It is this sericin, a natural gum secreted by the silkworm, which bonds the two filaments together in a protective sheath. (This is why the cross-section of silk thread is like an electric cable). This gum is later partially or totally removed by a process called boiling-off (or degumming) but it performs the function of protecting the fibroin during the mechanically stressful operations of twisting and weaving. The diameter of the bave is too fine for it to be used alone. For a silk thread to be used as a textile fibre it must be composed of at least four baves, i.e. the produce of four cocoons. The operation which consists of assembling the baves is known as reeling. [5]

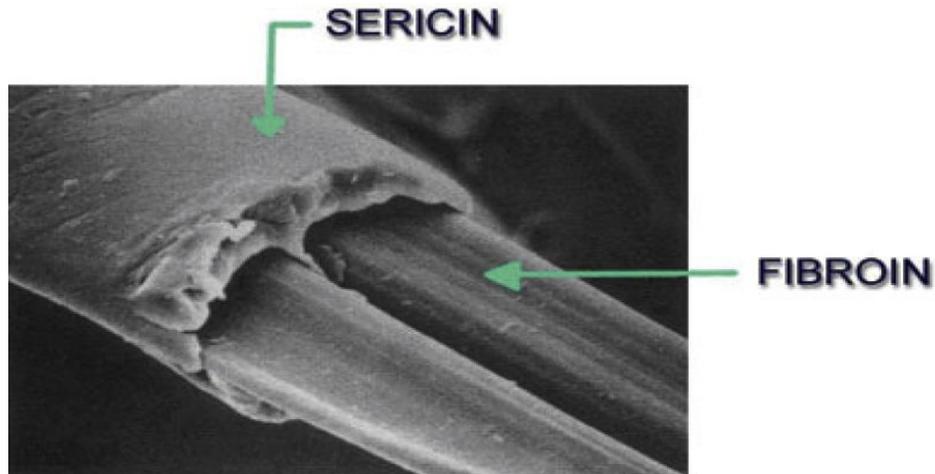


Figure 2: Cross section, longitudinal view and perspective of silk filaments.

4. Chrysalis (pupa)-When it has finished spinning its cocoon the caterpillar changes into a chrysalis and after that into a moth, if the normal life-cycle is allowed to continue. The moth emits a brownish liquid to soften one end of the cocoon and enable it to emerge by pushing its way through the threads. These cocoons cannot be used for reeling. The chrysalis is stifled by hot air before it can reach maturity (except for those kept for reproduction). The surviving male and female moths are mated and almost immediately after the female lays 350 - 500 eggs, which are preserved in cold storage until the incubation period when the whole cycle starts again.

Life cycle of silkworms (*Bombyx mori*)

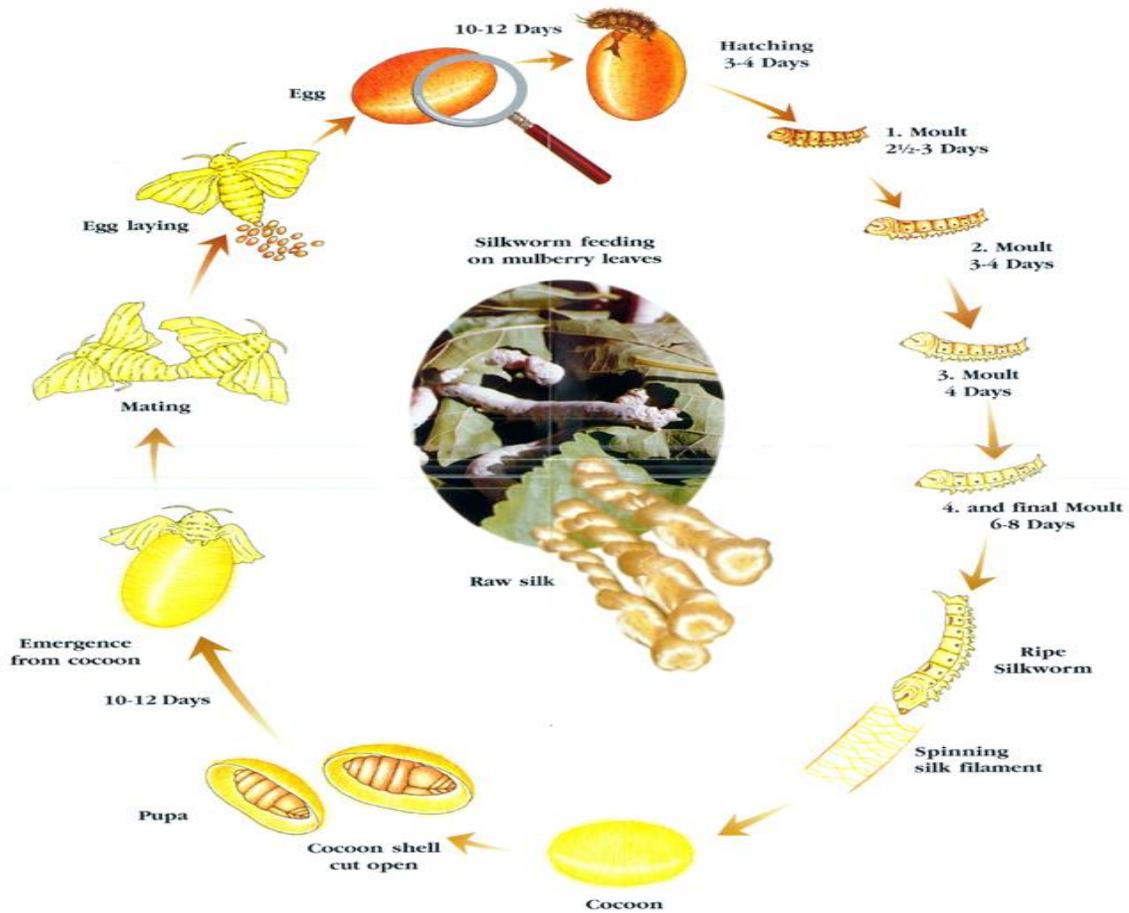


Figure: 3 Silk worm life cycle

Reeling of silk

After the chrysalis has been stifled and dried, three more operations are required before reeling. The cocoons are cooked in water at near boiling temperature so as to soften the gum (sericin) on the outer layers. Then mechanical brushes beat the cocoons to loosen the floss which is a mass of short fibres on the outside of the cocoon. Purging –it means removing the floss and picking up the end of the continuous filament forming the cocoon, which can reach as much as 1,600 metres in length.

Once the cocoons have been thoroughly prepared in this way, they are placed in a reeling-basin in which the water is kept at a temperature of 50°C (122° F). The silk is assembled the baves of 4 - 12 cocoons, according to the thickness of yarn required. The thread thus assembled is fed over a series of pulleys and at the same time is very lightly twisted ('croisure') to ensure good cohesion between the baves. It is then taken up on a reel or swift, which is a sort of very large bobbin. The yarn thus obtained after the reeling stage is known as raw silk. It is packaged on skeins.

Types of Silk

There are four major types of silk of commercial importance, obtained from different species of silkworms which in turn feed on a number of food plants. These are: mulberry, tasar, eri and muga. Except mulberry, other varieties of silks are generally termed as non-mulberry or wild silks. India has the unique distinction of producing all these commercial varieties of silk.

1. Mulberry



Figure-4 Mulberry Silk

The bulk of the commercial silk produced in the world comes from this variety and often silk generally refers to mulberry silk. Mulberry silk comes from the silkworm, *Bombyx mori* L. which solely feeds on the leaves of mulberry plant. These silkworms are completely domesticated and reared indoors. In India, the major mulberry silk producing states are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir which together accounts for 92 % of country's total mulberry raw silk production [4].

2. Tantalizing Tasar

Tasar (Tussah) is has a natural copper tone, it is a coarse silk mainly used for furnishings and interiors. It is less lustrous than mulberry silk, but has its own feel and appeal. Tasar silk is generated by the silkworm, *Antheraea mylitta* which mainly thrive on the food plants Asan and Arjun. The rearings are conducted in nature on the trees in the open. In India, tasar silk is mainly produced in the states of Jharkhand, Chattisgarh and Orissa, besides Maharashtra, West Bengal and Andhra Pradesh. Tasar culture is the main stay for many a tribal community in India. India is the second largest producer of tasar silk and the exclusive producer of Indian tasar (also known as tropical tasar).

Oak Tasar: It is a finer variety of tasar generated by the silkworm, *Antheraea proylei* J. in India which feed on natural food plants of oak, found in abundance in the sub-Himalayan belt of India covering the states of Manipur, Himachal Pradesh, Uttar Pradesh, Assam, Meghalaya and Jammu & Kashmir. China is the major producer of oak tasar in the world and this comes from another silkworm which is known as *Antheraea pernyi*.



Figure 5: Tasar Silk

Oak tasar is also known as temperate tasar and is mainly used for furnishing, dress materials and sarees. Bomkai, Paithani, Ikkat (tie & dye) and Katki are some popular fabrics produced using tasar silks. Bafta is a popular blend of tasar and cotton. Shawls and mufflers are also produced using a blend of oak tasar and other natural fibers like wool, cotton, etc. Tasar silk is ideal for making jackets for men and women or traditional costumes like the 'salwar-kurta'. This silk can be styled into beautiful dresses, stoles and scarves. Tasar fabric can also be printed, hand-painted, or, even embroidered into traditional sarees and beautiful dress-materials. Though there is no recorded document available regarding the origin of tasar in India, one can find the mention of tasar silk in ancient epic Ramayana "Ram's nuptial gift to Sita includes tasar silk". In fact, in India, it is said that a bride's trousseau is never complete without a saree made of Tasar Silk!

2. Irresistible Eri

Also known as Endi or Errandi, Eri is a multivoltine silk spun from open-ended cocoons, unlike other varieties of silk. Eri silk is the product of the domesticated silkworm, *Philosamia ricini* that feeds mainly on castor leaves. Ericulture is a household activity practiced mainly for protein rich pupae, a delicacy for the tribal. Resultantly, the eri cocoons are open-mouthed and are spun. The silk is used indigenously for preparation of *chaddars* (wraps) for own use by these tribals. In India, this culture is practiced mainly in the north-eastern states and Assam. It is also found in Bihar, West Bengal and Orissa.



Figure 6: Eri Silk

These worms feed mainly on Castor and Kesseru. As eri cocoons are open ended, the yarn is spun. Elegantly designed eri shawls and chaddars are quite popular because of their thermal properties. They can be blended with cotton, wool, jute or even mulberry silk to create exotic fabrics for use in jackets, or suiting material, or for producing a variety of furnishings, making it an interior decorators delight.

The word eri means castor plant, is derived from the word "eranda" of Sanskrit origin. The advent of Ericulture is lost into the antiquity but, the fact remains that Assam was the original home of eri silk from time immemorial, with the earliest reference documented in 1779. The Britishers

called it as "Palma Christi" silk. The eri silk was woven into heavy clothes known as "Bar Kapoor". Captain Jenkins (1771) remarked that eri silk was of incredible durability. [2]

4. Magnificent Muga



Figure 7: Muga Silk

This golden yellow colour silk is prerogative of India and the pride of Assam state. It is obtained from semi-domesticated multivoltine silkworm, *Antheraea assamensis*. These silkworms feed on the aromatic leaves of Som and Soalu plants and are reared on trees similar to that of tasar. Muga culture is specific to the state of Assam and an integral part of the tradition and culture of that state. The muga silk and high value product is used in products like sarees, mekhalas, chaddars, etc.

The most expensive of silks, muga is intrinsically woven into the cultural traditions of the people of Assam. The vibrant *sualkuchi sarees* and *mekhla-chaddars* are the traditional items made from muga silk. In recent times, fashion designers have found exciting prospects in using muga silk for developing new products and designs. Use of muga yarn as a substitute for 'zari' in sarees is finding favour with reputed weavers. The silk of Assam (Muga) was made known to the World during 1662 through a famous European traveller Jean Joseph Tavenier.

Uses of silk

- Silk is mainly used in the manufacture of clothing such as dresses, ties, shirts, trousers, pajamas, underwear and folk costumes. It is also used in skiing garments because of its lightweight and its ability to keep body warm.
- Silk is also used to make silk comforter or duvets which are lightweight and hypoallergenic. It is also used as fabric for upholstery, curtains, rugs and bedding such as sheets.
- Silk is sometimes used in the construction of parachute materials and cords. It is also occasionally used to make the casing of bicycle tires; cotton and nylon are also used for this purpose.
- For biomedical applications, protein based natural fibre such as silk; feather and spider silk fibres are suggested rather than other type of plant based natural fibre. Silk fibres as sutures for human wound dressing have been used for centuries [12]. Recently, regenerated silk solutions have been used to form a variety of biomaterials, such as gels, sponges and films, for medical applications [13]. Moreover, silk has been exploited as a scaffold biomaterial for cell culture and tissue engineering in vitro and in vivo [14].
- Silk has been used to make disposable cups and tableware.
- Due to its refractive nature holograms have been made using silk material.
- It has been used to create capsules for drug delivery.

- Spider silk was once used to create the cross hairs in instruments such as microscopes and telescopes. Spider silk is still used in the field of optics to create fine diffraction patterns needed in optical communications.

Health Benefits

Silk is renowned as “the queen of fibers”, “a source of beauty”, “a healthy fiber” and “a health protection fiber”. Its unique function to enhance the human body’s health is incomparable and irreplaceable by any other known fibers. Silk cloth can prevent ultraviolet rays from penetrating human skin, and repels germs, acting like a natural guardian. [4]

1. Ultimate comfort

Famous also as a “2nd skin” of human beings, silk is rich in natural protein & 18 kinds of amino acid, which resembles almost all the amino acids in human skin, giving it the highest biological compatibility with our human body. The fabric’s surface is smooth and silky, with an abrasion ratio of only 7.4% when touching human skin, the lowest among all the fibers. This gives it the ability to tenderly caress skin with its unique softness and texture, and adapt to the curves of body contour. There have been reported benefits of sleeping on silk. It helps in reduction of friction while sleeping and this in-turn helps in reduction of tangling of hair.

2. Great hygroscopicity and moisture releasability (Keeps you cool in summer and warm in winter)

The protein fiber of silk yarn is rich with many hydrophilic radicals including -CHNH and -NH₂, and due to its porosity, which enables the easy diffusion of water molecules, silk can absorb as well as release moisture into and from the air, allowing it to keep itself at a moderate and appropriate degree of moisture. Under the normal temperatures, silk helps the skin to comfortably moisturized to avoid dryness, while in summer season; it can diffuse sweat and heat released from the body to make you feel cool and comfortable. Due to its unique characteristics, silk is the best fabric available for direct contact with human skin.

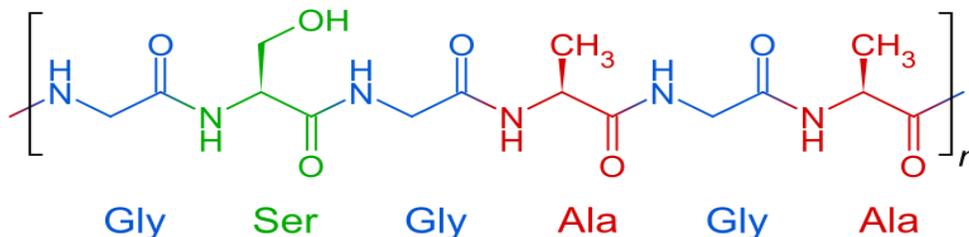


Figure: 8 Structure of Silk

The magic of silk is not only that it can keep you cool in summer, but it can also keep you warm in winter. Its great warmth-retaining properties result from its “multi-pore” fiber structure. In each silk yarn fiber reside many smaller fibers, inside of which even tinier fibers exist. So the seemingly solid silk yarn actually holds 38% of its volume as air, giving it a “hollow heart” which prevents warmth from escaping, making silk a naturally great “thermal protector”.

3. Sound absorbing, anti-dust, insulating, cooling & fire retardant.

Silk fabric, with its high quality of voidage, has proven to be a very good sound absorber. So besides being great in the apparel industry, it is also very suitable for home furnishing purposes such as

blankets, carpets, curtains, wall paper, etc, making the room almost dust-free and very quiet. Silk can also influence room temperature and get rid of hazardous air, dust or germs. Moreover, silk is even flame-retardant. The burning temperature of silk is 300-400°C, and when you heat silk to 100 C, only 5%-8% becomes burnt, while other synthetic fibers are very likely to melt and completely catch fire. Therefore silk is also the best material for interior decoration, as it is not only sound absorbing, anti-dust, insulating and cooling, but also fire retardant.

4. UV (ultraviolet ray) resistant.

Silk is naturally UV resistant as it contains “Tryptophan” & “Tyrosine” within its fibroin, it can absorb UV rays, which is excessively harmful to human skin. However, while protecting human skin from being damaged by UV, the absorbed rays cause a chemical reaction to silk fibroin, meaning that with excessive exposure to sunlight, a yellowish or faded look on silk products can occur.

Conclusion

With the above in mind, silk is indeed the most ideal fabric to use at home and in the furnishings industry. From ancient to modern times, silk has always been regarded as the most luxurious product that represents the ultimate comfort one can possess in daily life.

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