RAW SILK PROPERTIES

The silk filament or bave forming the cocoon though apparently single is actually composed of two filaments or brins which issue from a pair of silk glands of the silkworm and are stuck together and covered by silk gum or sericin. The presence of gum makes the silk feel harsh and stiff. In some varieties sericin looks coloured due to a mixture of colouring pigments in it. By a process of scouring or degumming, sericin can be separated from the brins. The amount of sericin varies from 22-30 per cent according to varieties of cocoons. Silk of commercial importance should possess certain physical and chemical properties which are enumerated below:

Length of Bave

The length of filament varies with the breed of worms. Generally speaking the univoltines and the bivoltines have a total length varying from 1000 to 1400 m of which about 75-80 per cent is reelable and the rest is removed as waste. The multivoltine pure races are poor silk yielders and build flossy cocoons which contain only about 350 to 600 m of which hardly 50 per cent is reelable. On the other hand, newly evolved multivoltine hybrids obtained through breeding experiments produce better cocoons with longer length of bave between 500 to 800 m of which over 60 per cent can be reeled.

Size of Bave

The size of the silk thread, bave or reeled raw silk, is expressed by the term denier. A denier is the weight of a length of 450 meters in 0.05 g units or the weight in one gram units of a length of 9000 meters. Thus if a sample of 450 m weighs 0.05 g or a sample of 9000 m weighs one gram, each sample is said to be one denier in size. The size of the bave is not constant throughout its great length but varies according to its position in the cocoon shell. The portion of bave forming the floss and outer covering of the shell is thicker than the bave of the middle compact reelable shell and the bave forming the inner most pelade layer. When denier of successive short lengths of the bave are taken from the beginning to the end, it is seen that the dimunition in size is not sudden but very gradual and that the bave can be likened to an enormously stretched cone. Although the general tendency is gradual dimunition in size, even in any short segment sudden thicknesses of the bave frequently occur due to uneven and lumpy distribution of the sericin. The dimunition in size is not serious in reeling firstly because the coarse bave of the floss and the too fine bave of the pelade are not used for reeling but are removed as waste; and secondly the dimunition in size of the reelable portion is very slight and extended over a great length. The average diameter of the bave is 15-20 microns for the univoltine and bivoltine races whereas for multivoltine races it is 6-14 microns. As the denier of bave is approximately proportional to the mean diameter of the bave, the uni-and bivoltines have generally larger denier than the multivoltine varieties.

Microscopic Examination of the Bave

The longitudinal view of the bave shows that the surface of the sericin layer is irregular and lumpy in places. Even under the covering of sericin, the inner brins can be seen as two smooth and transparent cylinders of fairly uniform thickness. Frequently the two brins are clearly separated for considerable lengths though the intervening spaces are filled with sericin.

In cross section, the shape of the bave is not uniform. The bave from the floss layer is slightly elliptical whereas that from the middle compact shell, which is reeled, is more circular. The bave from the pelade is fine in size and distinctly flat and ribbon like. The enclosed brins, however, appear as equilateral triangles with rounded off angles, facing each other at their flat sides.

In the longitudinal view, the degummed bave shows two brins as lustrous, compact and homogeneous rods of more or less constant thickness. When the brins are soaked in a 2.5% solution of sodium hydroxide for twenty four hours and later the fibre is crushed, the fibre is seen to break up into a number of minute fibrils, thus indicating that the apparently structure less brin is fibrillous in structure. The thickness of each fibril is about one twentieth of the normal filament or less than one micron. The fibrils run parallel to the axis of the fibre. In certain silkworm varieties which produce thick baves, the fibre splits into its constituent fibrils which stand out from the main fibre as minute hairs. The appearance of hair-like projections of the fibre is known as lousiness. Lousiness is more frequent in the middle layer of the cocoon shell and least in the inner most layer. It is also more frequent in baves produced by worms which have been overfed in their fifth stage. The other cause of lousiness is mounting of over-mature larvae. The defect of lousiness is less in breeds of silkworms which spin finer bave.

The characters of size and shape of the brins are important to the manufacturers of silk fabrics because it is on these qualities that the effect of dyeing depends. Yarn made from large diameter brins, or those flatter in cross section, dye darker than those from smaller brins with nearly rounded cross section. Lousiness is a serious problem to the manufacturers of all fabrics particularly smooth satins and neck-tie material because, when fabrics woven with such silk are dyed, they appear as if lightly covered by dust or show a paler shade than the main fabric due to the greater transparency of the protruding fibril and its smaller absorption capacity for dyes. Lousiness does not usually become a problem if the occurrence of projecting fibrils does not exceed 100 to 150 per 1000 m of thread.

X-ray of Silk

X-ray photographs show definite X-ray spots, which indicate that fibroin is crystalline in structure. The crystals are less than one tenth of a micron long and a few thousandths of a micron thick. A single fibre is therefore made up of an incredibly large number of crystals with the result the sum total of all the surface area of the crystals is very much more than the outer visible surface of the fibre. It is for this reason that silk has a great water absorption quality. When water has been absorbed the silk swells appreciably to the extent of nearly 33 per cent of its original thickness but the extension or lengthening of the fibre is not as conspicuous because the crystals are more than twenty times longer than their thickness.

Hygroscopic Nature

Hygroscopic properties of raw silk are commercially very important. Silk is very hygroscopic and is capable of absorbing up to 30 per cent of its weight of moisture, when exposed to saturated conditions of atmosphere without feeling wet or dry. But when bone dry silk is kept for a specified time in a standard atmosphere having 65 per cent humidity at 25ºC, the silk absorbs only 11 percent of its weight if the silk is raw and 10 per cent if it is in degummed condition. This is the accepted moisture regain coefficient of silk, and mercantile weight of silk is calculated accordingly.

Tensile Strength

Silk has enormous tensile strength with a breaking load of nearly 5000 kg per cm^3 or as much as 4 g per denier. It has an elongation of about 20 per cent of its original length before breaking. The elasticity is relatively less. It can be stretched only one to two per cent before it has a permanent set. Excess moisture increases the weight and elasticity of silk but decreases its breaking strength.

Tenacity of silk varies with the breeds of cocoons and, in the same cocoon, the tenacity per denier increases from the exterior to the interior of the cocoon while the elasticity varies inversely. Degummed bave has greater tenacity than raw bave.

Density of Silk

Raw silk has a density of 1.33where as degummed silk has a density of 1.25. Although these are the accepted standards of density, it is not absolutely constant for all varieties of silk but within small limits it varies with the breed of cocoons. About 65 per cent of the volume of silk is solid and about 35 per cent vacuoles.

Degumming Losses

Sericin which is the soluble portion of the bave forms between 22-30 per cent of the whole weight. As sericin is unevenly distributed in the bave, the percentage of loss is not uniform in all segments of the bave.

Scroop

Another property of silk which is peculiar to the fibre is its "scroop". This refers to the crackling sound emitted when the fibre is squeezed or pressed. The well known "rustle" of silk fabrics is due to the property of scroop. The scroop of silk however is not considered as an inherent property but rather acquired in the manufacturing process by treating in a bath of dilute acetic or tartaric acid and drying without washing.

Electrical Properties

Silk is a poor conductor of electricity and accumulates a static charge by friction, which at times renders it difficult to handle in the manufacturing process. The charge can be dissipated by high humidity or by maintaining 65 per cent R.H. at 25°C. Owing to its insulating properties silk is extensively used for covering wire in electrical apparatus.

Effect of Light

Silk is sensitive to weakening by ultra violet light. It loses as much as 50 per cent of its strength after six hours exposure to ultra violet light. Scoured silk requires a much shorter time for tendering. Silk in the form of fabric is readily damaged by sunlight.

Effect of heat

If white silk is heated in an oven at 110.5ºC for 15 minutes it begins to turn yellow. Above 170ºC silk disintegrates and on burning, it gives out an empyreumatic odour.

Action of Water

Water does not permanently affect silk fibre. Its strength decreases about 20 per cent when wet but regains the original strength upon drying. The fibre swells, but does not dissolve when steeped in warm water.

Silk is a highly absorbent fibre and readily becomes impregnated with water. Dissolved substances present in the water are also absorbed along with the water. It is for this reason that considerable importance is given to the quality of water for reeling, washing, dyeing or finishing. In most modern silk mills water is softened by the zeolite process and the hardness reduced practically to zero.

Action of Acids

Concentrated sulphuric and hydrochloric acids dissolve silk. In strong hydrochloric acid silk is dissolved in one or two minutes. Sulphuric acid takes a much longer time. If silk is treated with strong sulphuric acid for only a few minutes, then rinsed and neutralized, the fibre contracts from 30 to 50 per cent in length and loses its lustre, and no further damage is done. This is taken advantage of in creping of silk fabrics. Similarly when silk is treated with dilute hydrochloric acid having a density of 29ºTw, it shrinks without suffering any loss of strength. This is advantageously used for producing creping effects. Nitric acid and orthophosphoric acid may also be used for creping silk material,

The action of nitric acid is peculiar as it produces a bright yellow colour on silk which can be removed by treatment with a boiling solution of stannous chloride. But when silk is treated for one minute with nitric acid of sp. gr. 1.33 at a temperature of 45ºC, the silk acquires a bright yellow colour which is permanent and fast also to light. This yellow nitro-silk can be further brightened by treatment with an alkali. With strong sulphuric acid nitro-silk swells and becomes a gelatinous mass resembling egg albumen.

Reaction of silk to tannic acid is somewhat like hide in that it absorbs a large amount of tannic acid from a cold solution and as much as 25 per cent of its own weight from a hot solution. The tannin so absorbed is not readily removed by treatment with water. Tannic acid is used as a mordant in weighting of silk.

Formic acid and acetic acid have no injurious effect on silk unless heated. When silk is treated at ordinary temperature with 90 per cent formic acid, it swells, contracts and becomes gelatinous in about two to three minutes. When silk in this condition is rinsed in water it returns more or less to its original condition and on drying becomes stiffer and more lustrous, without loss of tensile strength. This method is sometimes used for improving the lusture of inferior silks but the disagreeable new lustre and the general tendering of silk in the process are against more popular use of the method.

Perspiration greatly tenders silk especially if the silk is weighted. Deodorants containing aluminium chloride render perspiration alkaline and thus cause perspiration tendering of worn silk material.

Action of Alkalies

Silk is not sensitive to dilute alkalies, though the lusture of the fibre is somewhat dulled. When treated with strong hot alkalies such as caustic soda or caustic potash, silk fibre dissolves. Ammonia and alkaline soaps dissolve only the sericin layer of silk but have no effect on the fibroin.

Continued boiling in such soaps for a prolonged period, however, affects fibroin. Borax has no action on either sericin or fibroin. If raw silk is steeped in lime water, the fibre swells to some extent and the sericin becomes soft. Continued treatment with lime water would render silk brittle. Ammoniacal solutions of copper and nickel salts are good solvents for silk. The nickel compound is sometimes used to separate this fibre from cotton.

Action of Metallic Salts

Silk has great affinity for metallic salts. This characteristic is the basis for the process of silk weighting, as it is claimed to improve draping properties of the fabric. Stannic chloride is commonly used for weighting unless the material is to be dyed black. From eight to ten per cent of tin salt is absorbed from a cold solution of stannic chloride. This amount of weighting does not injure the material but tends to increase the breaking strength.

Black silk is often dyed and weighted by using log-wood and iron salt. 'If the weighting has been properly done, slightly more than one fourth of the weight lost in degumming may be added without noticeable injury to the fabrics.

Action of Dye Stuffs

Silk has a greater affinity for dye than any other textile fibre. It absorbs dyes at a low temperature, and, being a protein, it possesses both acid and basic properties and therefore can be dyed with basic or acid dyes. Acid colours are dyed in strong acid baths some of which are fast to light and others fast to washing. Direct colours are used to dye silk preferably in neutral or weak alkaline solutions. Basic colours may be dyed in either weak acid, neutral or slightly alkaline solutions. Vat colours are soluble only in fairly strong alkaline solutions, but alkalinity should be kept as low as possible to dissolve the dye stuff.
