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MOISTURE REGAIN AND CHEMICAL CHARACTERISTICS OF PAKISTANI WHITE AND YELLOW SILK

ARJAMAND KHAN and NOORUDDIN AHMED WARSI

PCSIR Laboratories, Peshawar

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The moisture content or moisture regain[1] of textile materials depends not only on the properties of the textile but also on external factors, the most important being the relative humidity and the temperature. The moisture regain of a textile depends on the vapour pressure and also on the temperature of its atmosphere; the moisture regain is greater the higher the vapour pressure but is decreased by a rise in temperature.

The interactions of moisture and fibres have many technical consequences, the weight changes are of direct financial importance, and they influence the composition of a blend or the apparent count of a yarn. The hygroscopic quality of textile fibres i.e., their ability to absorb and desorb water is of great importance from many standpoints especially the comfort of the wearer when used for clothing. The relationship of moisture with fibre has an important bearing on many of the technical processes which they undergo in the course of manufacturing yarns and fabrics. The physicochemical characteristics and rheological properties of natural fibres are often highly dependent on the relative humidity of the atmosphere because of the moisture which they readily absorb by their moisture regain. The amount of moisture varies considerably according to the humidity and temperature of the atmosphere and for commercial transactions international metric system is used for silk and official value of moisture regain has been agreed on in the United States, Italy, France, Switzerland, Germany and Spain. With this purpose in mind the measurements of moisture regain have been confined to Pakistani white and yellow silk under different conditions of humidities and results evaluated. Some of the chemical characteristics of Pakistani white and yollow silk have now been studied and the results are presented in this paper. The amino acid composition and mechanical properties of Pakistani white and yellow silk have been reported earlier.[2]

Experimental

The determination of chemical characteristics and the rates of both absorption and desorption under different conditions of humidities were carried out on silk cocoon threads, reeled fibres and degummed fibroin. The temperature was 20°C about and the relative humidity being 65% approximately.

1. *Threading.*—The silk cocoon was threaded by simply sorting of cocoon filament with the help of forcep.

2. *Reeling.*—Reeling of silk was done in a bath containing 1 l of boiling water. The cocoons were steeped in a boiling water-bath for 1–2 hr and the free ends of cocoon filaments were drawn.[3]

3. *Degumming.*—The reeled silk was then degummed by soap–alkali treatment as laid down by Hartsuch.[4]

4. *Determination of Per Cent Moisture Regain.*—The silk sample (8–10 g) was weighed in round glass bottle and heated in an oven at 140°C for 5 hr to constant weight as recommended by Milan commission (1906).[5] The per cent moisture regain referred to in this paper is defined as a ratio of the moisture content to the weight of dry sample multiplied by 100. Thus% moisture regain$=100(a-b/b)$ where a=total weight of sample including moisture, and b=weight of dry sample.

5. *Determination of Absorption and Desorption Properties of Pakistani White and Yellow Silk with Relative Humidity Chamber Method.*—A wooden chamber of inner dimensions $3\times2\frac{1}{4}\times3$ ft was designed for the determination of absorption and desorption properties of silk under different conditions of relative humidities. Four heaters were attached to the inside of a wall of the chamber and a polymeter hanged at the top of the chamber. The chamber was ventilated with small holes and in addition a desert cooler and a blower were provided so as to maintain manually constant the required relative humidity. The silk specimen was first of all conditioned to about 10% relative humidity for 3 hr then subsequently conditioned for 3 hr at different relative humidities. The per cent moisture regain of absorption for a series of ascending relative humidities of 20, 30, 35, 40, 50 and 65% was determined. For the determination of desorption the silk specimen was first conditioned at 70% relative humidity for 3 hr approximately in the usual manner as was done for absorption and then at a descending series of relative humidities. The per cent moisture regain of desorption was calculated for the values of 65, 50, 40, 35, 30 and 20% relative humidities. The per cent moisture regain of absorption and desorption were calculated in the usual way as mentionedpreviously.

6. *Moisture.*—For moisture content (9–10 g) of cocoons, reeled and degummed silk were heated at 140°C for 5 hr to constant weight in an oven.

7. *Ash.*—The ash percentage was determined first by heating (4–5 g) cocoon threads, reeled and degummed silk at 140°C in a covered porcelain crucible in an oven to expel moisture and then heated in a Muffle furnace at about 800°C for about 4 hr until the ash attained a constant weight as shown by cooling the crucible in a des-

sicator and weighing. The ash content was calculated on the weight of the oven-dried sample.

8. *Nitrogen.*—The nitrogen content was determined by the microkjeldahl method recommended by A.O.A.C.[6]

9. *Wax and Fat.*—Silk cocoon threads and reeled fibres (5.0 g) was placed in a filter paper thimble in a Soxhlet apparatus and extracted by means of light petroleum (b.p. 60–80°C) for 5 hr the extract was filtered, the solvent recovered by distillation. The wax and fat so obtained in container was dried in an oven for ½ hr at 105 ± 2°C, allowed to cool and weighed as recommended by Truter[7] and Lomax[8]

Results

In Tables 1 and 2 are listed the per cent moisture regain of absorption and desorption under different conditions of humidities and the results represent the mean value of eight separate determinations. Table 3 gives the results of certain chemical characteristics of Pakistani white and yellow silk. Each result of chemical items represents the average of eight separate determinations.

Discussion

The hygroscopic quality of silk is of considerable commercial importance as the weight of any given lot of silk in any form will vary within large limits according to climatic conditions. The importation of silk involves duty considerations, the true weight should bebased on a standard percentage of moisture content or moisture regain. Consequently for commercial purposes standards of moisture

TABLE 1.—WATER ABSORPTION OF PAKISTANI WHITE AND YELLOW SILK.

Relative humidity %	Moisture regain %					
	White			Yellow		
	Cocoons	Reeled	Degummed	Cocoons	Reeled	Degummed
20	6.13	4.90	3.84	6.68	5.58	4.70
30	7.25	6.12	5.43	6.83	6.46	5.43
35	8.14	7.41	6.35	8.25	7.45	6.37
40	8.32	7.85	6.54	9.14	7.93	6.67
50	9.28	8.67	8.06	9.62	8.21	8.08
65	10.16	9.29	8.45	10.49	9.37	8.53

TABLE 2.—WATER DESORPTION OF PAKISTANI WHITE AND YELLOW SILK.

Relative humidity %	Moisture region %					
	White			Yellow		
	Cocoons	Reeled	Degummed	Cocoons	Reeled	Degummed
65	11.56	10.42	9.76	11.64	10.47	9.84
50	10.62	9.83	8.64	10.73	9.90	8.89
40	9.81	9.04	7.80	10.12	9.14	7.83
35	9.60	8.65	7.73	9.94	8.68	7.76
30	8.57	7.53	6.02	9.05	7.92	6.95
20	7.54	6.09	4.85	8.36	6.73	5.54

TABLE 3.—THE PERCENTAGE CONTENT OF CHEMICAL COMPONENTS OF PAKISTANI WHITE AND YELLOW SILK.

Chemical constituents	White			Yellow		
	Cocoons	Reeled	Degummed	Cocoons	Reeled	Degummed
Moisture	10.42	9.29	8.15	10.64	9.48	8.25
Ash	1.98	1.86	1.12	1.38	1.23	1.09
Nitrogen	—	—	18.12	—	—	18.27
Wak and fat	1.38	0.78	—	2.86	1.17	—

content or moisture regain for Pakistani silk in its various forms have been established in this study.

From technological point of view the absorption of moisture is a valuable feature of clothing materials. The removal of surplus water from textile materials after wet processing is an important operation in textile finishing and at other stages in manufacture. In general dyeing technique is closely associated with the moisture relation of fibres as those fibres which have got more affinity with water are easier to dye, more prone to microbiological attack, less prone to static electrification and better conductors of electricity.

The measurement of moisture regain is of great importance in silk industry principally for controlling the standard weight of commercial transactions and the numerous stages in manufacture; in nearly all of which moisture regain is a factor which determines the quality or uniformity of the product or the efficiency of the process. Transportation of silk from one locality to another of different humidities and temperatures causes loss or gain in the apparent weight of the silk as the moisture is absorbed or desorbed by the silk from the atmosphere, if the relative amount of moisture is lesser or greater than that in the silk. Such type of changes arises due to differences between the vapour pressure of the atmosphere and that within the silk.

It is clear from Table 1 and 2 that weight of silk is profoundly affected by the humidity of the atmosphere in which it is stored. This is due to the fact that water is not tightly bound to silk fibres. The absorbed water is being always escaped from silk and at the same time bombarded by the water molecules in the atmosphere until equilibrium is established when the rate of escape of water molecules is equal to the rate of bombardment.

The amount which is absorbed by silk fits conveniently into its structure; silk and water molecules are intimately mixed. The possibility for this arises from the fact that silk fibroin contain within its molecules groups which strongly attract water for example carbonyl (—C=O) in the main-chain and other active groups in the side-chains. The geometric arrangement of the silk fibroin molecules may also play a part and the probability cannot be precluded that amorphous regions of silk fibroin may be freely accessible to water molecules but the interiors of regions in which the molecules have crystallised may usually be inaccessible. This would be expected that the molecules in noncrystalline regions are linked together only at few points, whereas in crystalline regions the long chain molecules are oriented more or less parallel to one another, being a compact net work, not easily deformed or swollen to allow additional water molecules to enter.

From the results of chemical analysis Table 3 it is seen that moisture content in white cocoons, reeled and degummed silk was found relatively lesser than yellow cocoons, reeled and degummed silk. The ash content in white cocoons, reeled and degummed silk was found higher than yellow cocoons, reeled and degummed silk. The nitrogen content of Pakistani white and yellow silk is almost constant. The wax and fat per cent was found different in white and yellow cocoons and raw or reeled silk, whereas the amount of this chemical component in yellow cocoons and reeled silk was found greater than the white cocoons and reeled silk. In white cocoons and reeled silk as well as in yellow cocoons and reeled silk the per cent wax and fat was found variable.

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