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REGAIN CHARACTERISTICS OF PAKISTANI SILK

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Abstract. Adsorption and desorption measurements have been made on white and yellow Pakistani silk both in the gum and the degummed form. Use of common laboratory facilities for the purpose has been discussed and suggestions for the official regain have been considered.

The moisture absorbed by the natural textile fibres from the atmosphere is of importance from technological, commercial and scientific standpoints. Thus, physical properties and processing behaviour are appreciably modified by the fibres' moisture content. Since regain (moisture content calculated on the basis of dry weight of the fibres[1]) is dependent on the nature of fibres, relative humidity and the temperature of the environment, a certain mean value called 'official regain' is agreed upon for the purposes of commercial transactions in respect of different fibres in many countries. As far as known, no such value has so far been suggested in the case of Pakistani silk.

The amino acid composition of Pakistani white and yellow silk (*Bombyx mori*) has earlier been studied.[2] Present study aims at investigating regain characteristics of both of these varieties for all humidities ranging from 0 to 100.

It may also be pointed out that, since regain is dependent on both R.H. and temperature, any study would require keeping one of these variables constant and varying the other. Since, however, the changes with temperature are relatively small,[3] the investigations involving changes in R.H. giving rise to 'isotherms', have attracted more attention.

The determination of regain is fraught with a number of difficulties[4] and consequently different approaches have been adopted. More especially, conditioning of fibres at different R.H. may be cumbersome as it may involve long periods. An additional objective of the present investigation is, therefore, to arrive at reproducible results adopting rather convenient laboratory conditions.

Materials and Methods

Cocoons. Two varieties of cocoons of white and yellow silk, belonging to the Baghdad and Chinadoor species, respectively, were obtained from the Sericulture Department, Peshawar.

Preparation. Reeling of the silk from cocoons was carried out in the laboratory employing distilled hot water. The raw silk so obtained was dried under room conditions.

The reeled silk was degummed essentially by the soap–alkali process.[5] Locally available soap, 15% by weight of the raw silk, was employed. The pH of the solution was adjusted at 10, adding drops of NaOH. The beaker was heated at constant temperature for 1½hr (96°), washed with distilled water, squeezed and dried.

Adsorption Measurements. The adsorption measurements were carried out employing essentially the desiccator method.[6,13] The exact dry weights of 1g specimens of silk contained in four weighing bottles were obtained by placing them over phosphorous pentaoxide contained in a vacuum-desiccator through which air was exhausted to a pressure of 100 mm until constant weight was obtained. In preliminary experiments, it was observed that employing these conditions, the sample could practically be dried in 4–5 days in comparison to drying at normal pressure over several weeks.

The saturated salt solution as prescribed (Table 1) was poured in a vacuum-desiccator and a thermometer was kept inside the desiccator to note the temperature. The bottles were then immediately placed in the desiccator and the lids were taken off. The desiccator was evacuated to a pressure of 100 mm and was placed either in a chamber fitted with a cooler (in summer) or placed in an oven so that the thermometer in the desiccator indicated a temperature of 25°C. In two cases viz. for 65% and 95% R.H., temperature advised for obtaining the R. H. was 20°C but for the sake of isotherms the temperature was, kept at 25°C. The change in the R.H. was, therefore, small as indicated by a hygrometer kept in the desiccator. It took about 4–5 days to reach at a practical equilibrium. Between 80–100% R.H., a set of five salts was employed to obtain gradual changes at this end of the curve, where readings are

TABLE 1. SALTS EMPLOYED FOR THE VARIOUS R.H. AT 25°C.[6]

Salt	R.H.(%)
$NaOH.H_2O$	7.0
$KC_2H_3O_2.1\frac{1}{2}H_2O$	22.5
$CaCl_2.6H_2O$	31.0
$K_2CO_3.2H_2O$	42.8
$Ca(NO_3)_2.4H_2O$	51.0
$NaBr.2H_2O$	57.7
$Mg(C_2H_3O_2)_2.4H_2O$(20°C)	65.0
$SrCl_26H_2O$	70.8
$(NH_4)_2SO_4$	81.1
KNO_3	92.5
Na_2HPO_4(20°C)	95.0
$K_2Cr_2O_7$	98.0
H_2O	100.0

rather prone to errors. The salts selected for the various R.H. have been reproduced in Table 1 for ready reference.

Desorption Measurement. For desorption, the same procedure was adopted as discussed above, but the salts were employed in the reverse order.

The temperature selected for most isotherms has been 20°C, but temperature of 27 or 25°C has been advised for tropical conditions.[7,11] Out of these, 25°C was selected for the present studies in view of the fact that this would be more consistent with the climate of our country.

Average Regain. In addition to the complete regain cycles, a number of regain estimates were made of the silk samples, conditioned at the room atmosphere at various times of the year. For this purpose dry weights were determined employing the usual oven method.[8]

Results and Discussion

On the completion of a hysteresis cycle on the four samples of silk, four fresh samples were taken from the same parent samples and another cycle was carried out. The results are given in Tables 2 and 3.

At each R.H. the samples were conditioned for at least 4 days. Although the equilibrium was arrived at in about 4–5 days, sometimes the samples were left in the same atmosphere for longer periods due to delay in the availability of the salt to be used for the next R.H. or interruption by weekends. Thus the first cycle was completed in about five months while the second in four months.

The results of the first and the second cycles in the case of the same type of silk were almost similar to one another, so that the hysterises curves so drawn were practically indistinguishable from one another. This indicates reasonable repeatability of regain cycles, conveniently employing such common laboratory apparatus and conditions as those used in the present study.

It is apparent from Table 4 that, under the conditions where R.H. seldom exceeds 65%, the regain is

TABLE 2. RESULTS OF THE FIRST CYCLE OF ADSORPTION–DESORPTION MEASUREMENTS (%).

R.H. (%)	Yellow raw silk		Yellow degummed silk		White raw silk		White degummed silk	
	Ads	Des	Ads	Des	Ads	Des	Ads	Des
7.0	2.49	3.40	2.30	3.19	2.23	3.19	2.00	3.01
22.5	5.02	6.10	4.63	5.69	4.82	5.82	4.62	5.42
31.0	5.70	6.93	5.52	6.72	5.33	6.41	5.00	6.02
42.8	7.30	8.55	7.00	8.26	7.09	8.12	6.88	7.93
51.0	8.42	9.69	8.00	9.29	8.21	9.41	7.89	8.98
57.7	9.30	10.58	8.87	10.12	8.73	9.91	8.39	9.53
65.0	10.90	12.15	10.18	11.40	10.64	11.85	9.98	11.09
70.8	11.00	12.26	10.68	11.98	10.70	11.99	10.40	11.50
81.1	15.00	16.25	14.08	15.37	13.88	15.07	13.03	14.18
92.5	20.15	21.18	19.04	20.60	19.37	20.79	18.25	19.56
95.0	23.50	25.30	23.40	25.13	22.98	24.56	20.98	22.45
98.0	31.12	33.22	28.06	30.07	26.73	28.66	24.13	26.01
100	39.48	39.48	37.72	37.72	35.99	35.99	33.57	33.57

TABLE 3. RESULTS OF THE SECOND CYCLE OF ADSORPTION–DESORPTION MEASUREMENTS (%).

R.H.(%)	Yellow raw silk		Yellow degummed silk		White raw silk		White degummed silk	
	Ads	Des	Ads	Des	Ads	Des	Ads	Des
7.0	2.58	3.64	2.41	3.37	2.21	3.21	2.04	2.99
22.5	5.09	5.22	4.67	5.57	4.72	5.70	4.61	5.61
31.0	5.93	7.12	5.90	7.12	5.86	6.88	5.29	6.27
42.8	7.28	8.51	7.18	8.41	7.15	8.23	6.73	7.87
51.0	8.54	9.86	8.29	9.49	8.39	9.52	8.20	9.30
57.7	9.51	10.86	9.07	10.36	8.97	10.00	8.74	9.81
65.0	10.85	12.15	10.31	11.55	10.60	11.75	9.50	10.58
70.8	11.03	12·32	10.76	11.96	11.07	12.17	10.11	11.17
81.1	14.79	16.08	14.31	15.56	14.01	15.12	13.42	14.51
92.5	19.87	21.33	19.28	20.67	19.43	20.70	18.20	19.38
95.0	23.57	25.43	23.00	24.78	22.22	23.91	20.97	22.56
98.0	30.98	33.15	29.75	31.75	27.64	29.64	25.02	26.91
100	38.61	38.61	37.91	37.91	36.43	36.43	35.15	35.15

TABLE 4. REGAIN OF SILK AT VARIOUS ROOM CONDITIONS.

Temp (°C)	R.H. (%)	Regain (%)			
		Yellow raw silk	Yellow degummed silk	White raw silk	White degummed silk
20	55	8.28	7.96	8.06	7.82
26	41	7.42	7.08	7.15	6.96
23	38	7.46	7.09	7.14	7.01
19	61	9.32	8.98	9.05	8.90
16	64	10.71	10.22	10.11	9.64
12	53	8.31	7.92	8.12	7.85
15	46	7.68	7.27	7.36	7.21
21	66	11.22	10.70	11.00	10.49
26	34	6.91	6.61	6.62	6.11
34	58	9.54	9.26	9.19	8.94

TABLE 5. COMPARISON OF RESULTS AT 65% R.H.

Sample	Temp. (°C)	Silk in the gum		Degummed silk	
		Ads	Des	Ads	Des
Japanese and Italian[11]	25	10.65	12.15	9.90	11.05
Italian	25	11.00	12.45	10.10	11.25
Japanese silk[12]	16–18	10.3	12.4	—	—
Organzine silk[12]	"	10.5	12.5	8.9	10.1
Yellow silk (this study)	25	10.88	12.15	10.26	11.48
White silk (this study)	25	10.63	11.80	9.74	10.84

TABLE 6. REGAIN OF SERICIN OF YELLOW AND WHITE SILK.

R.H. (%)	Yellow sample		White sample	
	Ads	Des	Ads	Des
7.0	3.25	4.24	3.15	3.91
22.5	6.28	7.74	5.62	7.42
31.0	6.42	7.77	6.65	7.97
42.8	8.50	9.71	7.93	8.88
51.0	10.10	11.29	9.49	11.13
57.7	11.02	12.42	10.09	11.43
65.0	13.78	15.15	13.28	14.89
70.8	15.68	13.38	11.90	13.95
81.1	18.68	19.37	17.28	18.63
92.5	24.59	26.65	23.85	25.71
95.0	23.90	25.98	30.98	33.00
98.0	38.36	45.82	37.13	39.26
100	46.52	46.52	45.67	45.67

generally low. As against this, the average trend of the regain at the standard atmosphere is indicated to be 11.0 from Tables 2 and 3. The low regain under practical conditions is apparently due to the fact that even if R.H. approaches 65%, it usually soon goes down and the fibres do not get sufficient time to have the expected regain. For commercial purposes, therefore, an official regain of 10.5, instead of 11.0, would be more consistent with practical conditions. Also, in view of these facts, an actual determination of regain is emphatically advised for commercial transactions.

The results indicate that the yellow variety has slightly higher regain under various conditions than the white one. Earlier, the amino acid composition of these varieties was studied[2] which indicated that the yellow variety was significally rich in alanine, proline, threonine and tryptophane, but poor in phenylalanine, tyrosine and isoleucine. Out of these, alanine and proline have relatively the highest tendency to dissolve in water[9,10] and this could well be, at least partially, the reason for the slightly higher regain of the yellow variety.

Table 5 gives, for convenience, a comparison of the results of present study with those of some other reports for the case of standard atmosphere. The results indicate similar trends except for the case of organzine silk,[12] which shows relatively higher drop in regain on degumming.

The higher regains of the silk in the gum in comparison to that of the degummed silk may well be attributed to the correspondingly higher regains of sericin present. Consequently Hutton and Gartside[13] have deduced regain for sericin from their results on silk regain. Similar deductions have been made from Table 2 of this study, on the basis of about 20% sericin content of these silks, and the results presented in Table 6 are in general agreement with those of the above authors.

Conclusions

Employing such common laboratory facilities as those in the present study viz. atmospheres of the various salt solutions and a partial vacuum (100 mm), reasonable estimates of regain of silk can be obtained in a few days so that a complete cycle can be carried out in about four months.

For the standard atmosphere of 65% R.H. and 25°C, a value of 11.0 is suggested for the official regain which, however, may be reduced to 10.5 in view of the practical conditions prevailing in Pakistan as discussed.

The reason for the slightly higher regain of the yellow variety may well lie in its constitution, especially in its richness in the alanine and proline.

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