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INVESTIGATION OF THE MUTUAL EFFECTS OF WATER FROM THE COCOON SHELL

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Annotation

Granularity significantly affects the wettability of the surface of the cocoon. The higher the height of the cocoon tubercles and the greater the wetting angle. Roughness fluctuations are insignificant for different hybrids, but they differ in shell layers. SAS solutions help change the polarity of the contact zone of the surface of the threads with the liquid, thereby changing the surface structure, increasing its hydrophobicity, thereby reducing surface tension and improving wettability and water permeability.

Introduction

The passage of water through the shell is achieved by hydrostatic pressure, which occurs as a result of the temperature difference in various technological zones, causing a change in air pressure inside the cocoon. In this case, the volume of water that has passed through the shell depends on the air and water permeability, wettability, packing structure, porosity, shell thickness, the duration of the temperature and, to a large extent, the pressure difference inside and outside the cocoon, as well as the state of sericin after primary processing, and the amount of water passed to some extent determines the degree of swelling of sericin and fibroin.

According to the natural properties of the shell itself, its water permeability in different zones is not the same due to the heterogeneous structure [1], since the cocoon thread differs in thickness in the outer and inner layers, and the thread itself is packed with different degrees of compaction over the surface and depth of the shell. In addition, sericin itself differs in properties that vary over the surface and in the depth of the layer [2]. The process of water penetration into the cocoon is also complicated by the fact that the shell contains air, the heating of which is accompanied by an increase in pressure inside the cocoon, which creates a certain additional resistance to water penetration. Water absorption by cocoons [3] even for the same breed and variety under equal processing conditions ranges from 5.5 to 15.5 cm^3.

The water permeability of the cocoon shell during steaming and unwinding is significantly affected by the wettability of the shell and the fibers themselves [4].

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Material and Methods

One of the main technological processes of steaming is the treatment of cocoons with hot water to soften the sericin and facilitate the unwinding of the thread. When parked and unwinded, the wettability of the sheath and the threads themselves has a significant effect. The phenomenon of wetting is observed at the interface of three phases, one of which is a solid, and the other two are liquids or liquid and gas. The nature of wetting is determined by the physicochemical processes occurring on the phase interface, one of which is the surface of the cocoon shell, and the other is the solution in which the cocoons are processed. Contact wetting is characterized by the value of the equilibrium contact angle (θ_0) between the surfaces and the liquid at the boundary with the environment.

Of practical interest is the development of a method for regulating wetting in the desired direction, which is the task of the physical chemistry of wetting. In the general case, the equilibrium shape of a drop is determined by the specific free surface energies of the three phases involved in wetting. In this case, the contact angle is characterized by the Young equation

$$\cos\theta = \left(\frac{\sigma_{sg} - \sigma_{si}}{\sigma_{is}}\right) \qquad (1)$$

Where: σ_{sg} - surface tension at the boundary of media solid-medium; σ_{si} -surface tension at the boundary of media solid-drop; σ_{is} surface tension at the interface between a drop and a medium.

The cases considered above relate to the wetting of a liquid on a smooth surface of solids, although ideally smooth surfaces are rare in practice. Typically, the surface of a solid body has numerous irregularities and rough nesses of various shapes and sizes that affect wettability.

The issues of wetting solid surfaces have been studied in detail for metals and some materials, but as for textile materials and natural silk cocoons, this pattern has not been studied enough.

The presence of irregularities increases the actual area of the solid surface by K times compared to a perfectly smooth plane. Accordingly, the adhesive attraction of the liquid to the solid surface increases by K times:

$$\tau_a = K(\sigma_{sg} - \sigma_{si}) \qquad (2)$$

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The surface of the liquid remains spherical. Therefore, the force preventing the increase in the wetted surface is equal to

$$\sigma_{is} \cos\theta_r \qquad (3)$$

This implies the condition of mechanical balance of forces on the wetting perimeter:

$$K\,(\sigma_{sg} - \sigma_{si}) = \sigma_{is} cos\theta_r \text{ and } cos\theta_r = K\cos\theta_0 \qquad (4)$$

The equation allows us to draw the following conclusions. In the absence of wetting, an increase in roughness leads to an increase in the macro contact angle. If the liquid wets this material, then an increase in the roughness coefficient causes a decrease in the macro contact angle [4].
Thus, the penetration of water into different parts of the cocoons occurs at an unequal speed, due to the inhomogeneity of the thread in terms of density, thickness and granularity. The outer surface of the cocoon has an uneven, lumpy-granular structure, and penetrating into the inside, they become smooth.

Results

Wetting of the cocoon shell depends on the surface roughness of the shell, the degree of its interlacing, thickness, and a number of other factors. There are cocoons with large, medium, and small, as well as with distinct and diffuse granularity [1]. The wetting process under consideration looks somewhat different for granular surfaces. We have studied the dependence of the height of the bumps on the size and caliber and their influence on the wettability of the cocoon shell. The study was carried out on cocoons of the hybrid Ipakchi 1 x Ipakchi 2 and cocoons of Chinese grains. The average value of both hybrids was taken. In finely tuberculate cocoons, the height of the tubercles is on average 0.03 mm, and the height of medium and large tubercles, respectively, is 0.06 mm and 0.08 mm (Table 1).
Naturally, the surface area increases as the number of tubercles increases. The granularity depends on the true and apparent surface area of the cocoon, cm^2.

Table 1. The influence of the height of the hillocks on the wettability of the shell

The size of the tubercles	Height of tubercles, mm	Number of bumps per 1 cm^2	Caliber of cocoons, mm	Shell wettability, θ, deg.
Small	0.01	48.8-53.8	12-15	105
Medium	0.02	40.1-48.3	16-17	115
Large	0.05	37.7-40.5	19-23	127

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Granularity significantly affects the wettability of the surface of the cocoon. It has been established that the higher it is, the greater the height of the cocoon tubercles and the smaller the wetting angle. With a large grain height, the bumps are smaller, which makes the surface more uneven, when coated with liquids, an uneven surface, air bubbles block the flow of the liquid inward and the contact angle increases.

The values of $\cos\theta_0$ were determined experimentally from the inside of the cocoon shell, and the value of $\cos\theta_ш$ was determined from the surface of the cocoon shell [5], and water was used as a wetting liquid (Table 2).

Table 2. Wettability of the cocoon shell by layers

Hybrids	Wettability of the smooth (inner) surface of the cocoon shell, θ_0	Washability of the rough surface of the cocoon shell, $\theta_ш$
Chinese grena	115	128
Ipakchi 1x Ipakchi 2	119	130
average value	117	129

Roughness fluctuations are insignificant for different hybrids, but they differ in shell layers. From the point of view of ensuring optimal steaming conditions, the contact angle of wetting of the shell should not exceed 90°. Since the surface tension of the wetting liquid affects the wetting angle, it can be expected that the addition of substances with surface activity to water should improve the wettability of the cocoon shell.

It is known that wetting control in various technological processes is based on the use of appropriate surfactants that can be adsorbed on the interface, reducing surface tension [6–8]. To study the wetting of the shell, we chose a nonionic surfactant. Comparison of the parameters characterizing the wetting angle of the cocoon on the surfactant concentration was carried out after 60 sec. after applying the solutions to the surface of the cocoon shell (table 3).

Table 3 Wetting of the cocoon shell on the concentration of SAS

Hybrids	Shell wetting on the concentration of SAS, %				
	0	0,1	0,2	0,5	1
Chinese grena	129	109	90	80	74
Ipakchi 1x Ipakchi 2	130	110	93	81	73
average value	129	110	91	82	74

Experiments show that the use of a nonionic surfactant causes a significant decrease in the angle , i.e. improves the wettability of the shell. The drug has an effective effect at a 0.5% solution, in which the contact angle drops to 47°.

Смачиваемость, град

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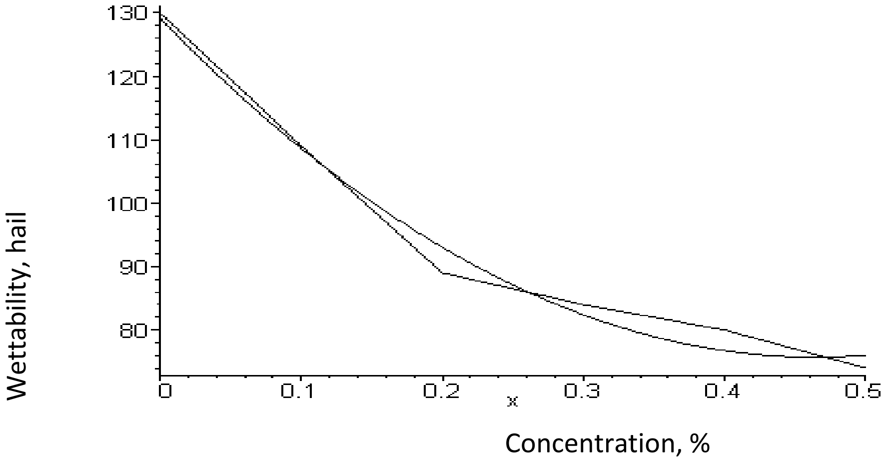

Fig. 2.2. Dependence of the wettability of the cocoon shell on the concentration of surfactants at a temperature of 25°C.

The curves characterizing the dependence of the wettability of the cocoon shell on the surfactant concentration are approximated by the following empirical equations.

$$y= 129{,}17857-230{,}3928\ x + 248{,}21428\ x^2$$

where: y-wettability; x-concentration

Conclusion

Granularity significantly affects the wettability of the cocoon surface. It has been established that the higher the height of the cocoon tubercles and the greater the wetting angle; fluctuations in roughness are insignificant for different hybrids, but they differ in shell layers; Based on the analysis performed, it can be assumed that surfactant solutions contribute to a change in the polarity of the contact zone of the surface of the filaments with the liquid, the formation of the orientation of polar groups towards the solution, and hydrocarbon chains towards the substrate, thereby changing the surface structure, increasing its hydrophilicity, thereby reducing surface tension and improving wettability and water permeability.

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