Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 4, 2021, Pages. 15097 - 15106
Received 05 March 2021; Accepted 01 April 2021.

Investigation the Structure of Defective Areas of Cocoon Shells and Their Influence on the Process of Steaming

Islambekova Nigora Murtozaevna[1*], Khaydarov Sanat Sunnatovich[1*], Muhiddinov Nuridin Muhiddin o'g'li[1], Azamatov Uchqun Nematovich[1], Rasulova Nargiza Fayzullayevna[1]

[1]Tashkent Institute of Textile and Light Industry Doctor of Technical Sciences Professor Department of Silk Technology Uzbekistan Tashkent City Yakkasaray district Shohjahon 5
E-mail: islambekova1968@mail.ru

[1]Tashkent Institute of Textile and Light Industry Assistant Department of Silk Technology. Uzbekistan Tashkent City Yakkasaray district Shohjahon 5
E-mail: khss1515@mail.ru

Is a basic doctoral student of the Tashkent Institute of Textile and Light IndustryDepartment of Silk Technology. Uzbekistan Tashkent City Yakkasaray district Shohjahon

Tashkent Institute of Textile and Light IndustryDepartment of Silk Technology great teacher. Uzbekistan Tashkent City Yakkasaray district Shohjahon 5

ABSTRACT

The article studies the change in the structure of the defective zones of the cocoon shell by means of microscopic studies of various colors of spots. The ability of the spotted areas to be cleaned of sedimentary substances was tested by preliminary soaking the samples at a temperature of 50 ^{0}C for 20 minutes in water and a 5 % soda solution. It was revealed as a result of the treatment of spotted cocoons in warm water, the sedimentary substance is partially dissolved, and with the use of treatment in a soda solution, defective areas are completely washed out.

The dependence of the solubility of sericin on time and on the concentration of the surfactant solution was investigated. With the addition of preparations - surfactant-1, surfactant-2 to the solution, the solubility of sericin improves. An increase in the solubility of sericin in the presence of surfactants can be explained by the interaction of charged groups in sericin molecules with the corresponding surfactant ions. leading to a total decrease in the activity of sericin and, in the presence of spots, facilitating its solubility.A study on the solubility and swelling of sericin in spotted areas showed that within 3-5 minutes at a temperature of 50^{0}C and a concentration of 0.4-0.5% corresponds to the lowest solubility of sericin and the best swelling. Revealed the presence of certain amounts of surfactants contributes to the minimum dissolution of sericin in clean and spotted areas of the cocoon shell and its uniform swelling, which will be beneficial in the process of unwinding cocoons.

Keywords
Shell, cocoon, defectiveness, fibroin, sericin, permeability, spots, color of spots, swelling, solubility, steaming, unwinding.

Introduction

The main criterion for grouping cocoons at the stage of preparing them for unwinding is defectiveness, taking into account both the defectiveness of the shell itself and the physicochemical and technical changes in the properties of the silk thread. In production conditions, taking into account the specifics of preparation for unwinding, cocoons are grouped into varietal ones, suitable for the production of high-quality raw silk; low-grade - providing a more or less uniform thread of increased linear density and defective - unwinding of which is practically impossible, or impractical due to increased unevenness and defectiveness of raw silk.

The belonging of each individual cocoon to one or another group is determined by the type of defect and the degree of its influence on the unwinding of the shell. According to the gradation of defects adopted in the silk industry, cocoons are divided into types, grouped by origin into: mechanical damage; defects in the structure and shape of the shell; physicochemical and structural changes in the properties of sericin and fibroin[1].

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Mechanical damage to the shell includes a group of defects formed during curling, in particular smooth areas, scars, fractures from mechanical deformation of the shell, the degree of influence of defects in this group is characterized by the relationship between the size of the defect and breakage during unwinding. Based on many years of practice in this parameter, satin cocoons with smooth areas and scars are divided into groups with small (up to 5 mm long), medium (up to 10 mm) and large (up to 15 mm) defects, and if the defect is longer than 15 mm, they are classified as to non-unwinding [2].

Cocoons with defects in the structure and shape of the shell are wholly the result of shortcomings in breeding work, violations of the agrotechnology of feeding and curling. These defects are not quantitatively assessed and are grouped only visually according to the degree of deviation from the shape inherent in the rock, indirectly taking into account the properties of their unwinding.

Cocoons with physicochemical and structural changes in sericin and fibroin represent the largest group of defects associated with changes both in the structure of the membrane itself and with chemical changes in sericin and fibroin of the cocoon filament. The origin of such defects is associated with caterpillar diseases (spotted, capercaillie), violation of drying regimes (hardened, overdried) and storage conditions (hardened, moldy) [3].

Literature Review

The formation of a smooth surface area of the shell occurs during curling, when the volume of free space of the cocoon is not sufficient for the formation of the cocoon and is limited either by a plane or by a face. If the shell contacts the cocoon along the plane, a flat smooth area is formed, and if along a curved surface, then a scar or thorn. When in contact with the plane, a part of the cocoon shell in cross-section is a chord of a circle, and its length is less than the length of the corresponding arc. In this case, the change in the linear size of the defective area is compensated for either by the compaction of the shell structure due to a denser packing of the filaments, or by a change in its thickness[4].

If we assume that in both cases the volumes of the deposited thread on equal areas of defective and defect-free sections of the shell are equal to each other, then any distortion of the shape is associated with a change in its resistance to the flow of gases and liquids. In the first case, this occurs due to a change in porosity, in the second, due to a thickening of the shell in a local area. The cross-section of the thread facing the contacting plane becomes flat. The surface of the filament facing the contacting plane becomes flat (Fig. 1. a.), And, due to an increase in the linear size in the direction of the plane itself, the pore sizes are reduced, porosity decreases and zones with increased resistance to gas and liquid flows are formed[5].

A similar change in the resistance of the shell to the flow of liquid or gas is observed in the scars and thorns formed when the cocoon contacts the side of the cocoon, a branch, or smooth surfaces (Fig. 1.b). In this case, with a uniform layer, the change in the porosity and resistance of the defective section of the shell is explained by a denser packing of the filaments, as in the case of a flat surface.

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Fig. 1. a

Fig. 1.b

Fig. 1. Satin cocoons: a) smooth surface; b) scars and thorns.

In addition, the boundaries of the defective zone have the character of a fracture with a discharged fibrous structure. When such cocoons are parked, water freely penetrates through the border areas, while the defective zones themselves remain dry. In a slightly different way, the technological properties of the cocoon shell are affected by spotty zones formed when the outer or inner surface of the shell comes into contact with the liquid released by the caterpillar during decomposition.

Spots are a solid residue that remains in the pores after moisture evaporates. In this case, the pores are partially or completely covered by sedimentary structures, reducing the size of living sections. Air pores and increasing the resistance of the area to air and water flow (Fig. 2).

Fig. 2. a

Fig. 2.b

Fig. 2. c

Fig. 2. Spotted cocoons: a) brown spots; b) brown spots; c) yellow spots

Changes in the structure of filaments on defective areas significantly affect the technological properties of the shell, especially on such parameters as steam, air and water permeability, capillarity, etc., determining the effectiveness of the subsequent steaming and unwinding of cocoons.

Due to the low yield of raw silk at certain sizes, defective cocoons are considered to be of low grade, due to the difficulties in unwinding them. The swelling of cocoons during steaming is known to be accompanied by partial dissolution of sericin, which, in the presence of defective areas, occurs unevenly over clean and defective zones, due to the difference in their interaction with the wetting liquid.

When unwinding, such cocoons often break off. In terms of chemical composition, the content of non-polar (hydrophobic) amino acids in defective cocoons, such as alanine, valine,

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leucine and isoleucine, is much higher than the amount of hydrophobic amino acid residues in the spotted areas of the cocoon shell, which is one of the main reasons for the uneven steaming of the shell[6-7].

By nature, the spots that appear during the processing have several varieties and are subdivided by color into spots of yellow, brown, brown, black, as well as spots on the inside of the shell (inside are spotty).

The reliability of the change in the porosity of the shell structure in the defective area is confirmed by the photographs of the layers taken at 40 times magnification of the satin cocoons (Fig. 3). The images clearly show a denser packing of fibers in areas with scars and smooth areas.

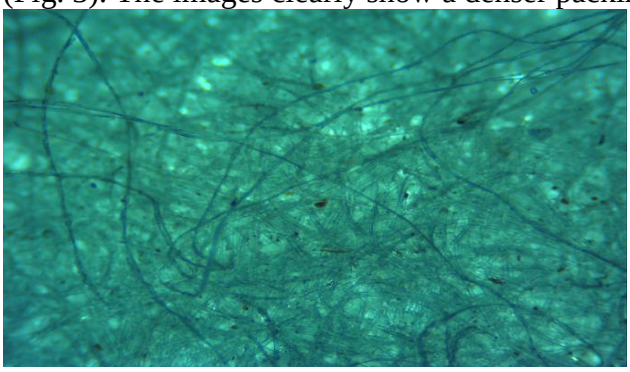


Fig. 3. a

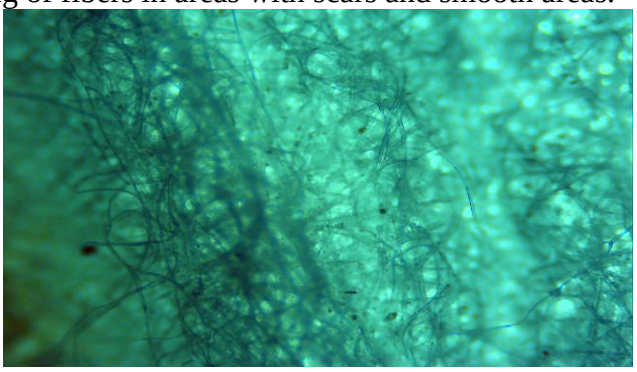


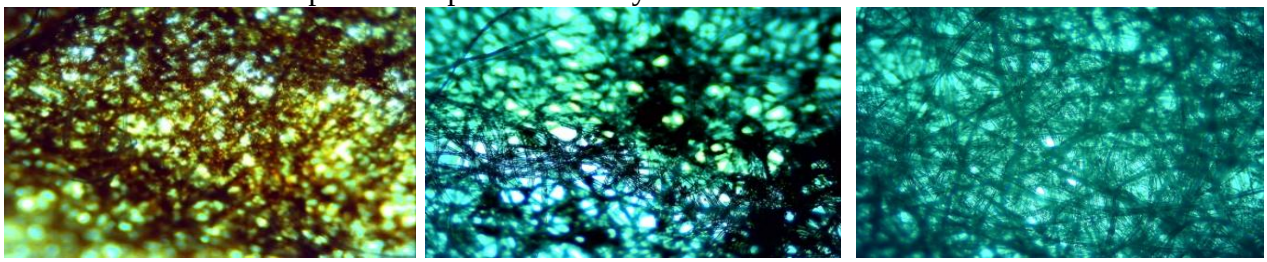
Fig. 3.b

Fig. 3 Satin cocoons: a) smooth surface; b) scar

To study the mechanism of the effect of the spots of the shell on the technological properties of the cocoons, we studied the change in the structure of the defective zones of the cocoon shell by microscopic studies of various colors of spots.

The studies were carried out on a microscope with 150 x magnification in the reflection mode, the ability of spotted areas to be cleaned of sedimentary substances was checked by preliminary soaking of the samples at a temperature of 50 ^{0}C for 20 minutes in water and 5 % soda solution. After locking, the samples were dried at room temperature and analyzed by the state of the surface. The microstructure of the areas of the shells in the spotted zones for different colors of the spot are shown in Fig. 4 - 8.

In the defective zones, the air spaces between the fibers are clogged with sedimentary substances remaining after the ingress of the liquid fraction of the coloring liquid. Such areas become practically impervious to air flow, complicating the steaming process. The structure, color and type of sedimentary substances depend on the nature of the origin of the coloring liquid and can have both amorphous and pronounced crystalline structure.



a b c

Fig. 4. Microscopic photographs of the surface of the thinned area of the yellow cocoon shell; a) untreated area; b) treated with water for 20 minutes. at 50 ^{0}C; c) treated with Na_2C0_3 solution for 20 minutes. at 50 ^{0}C.

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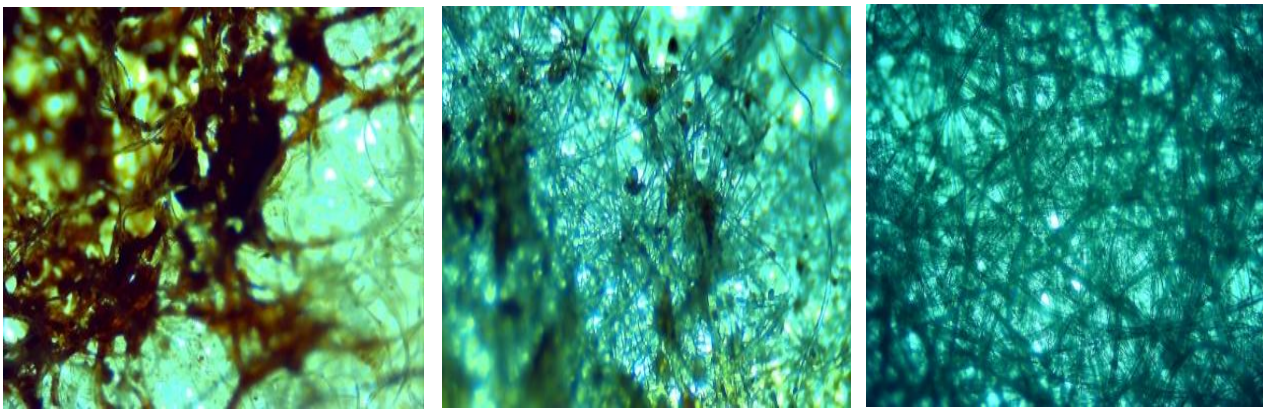
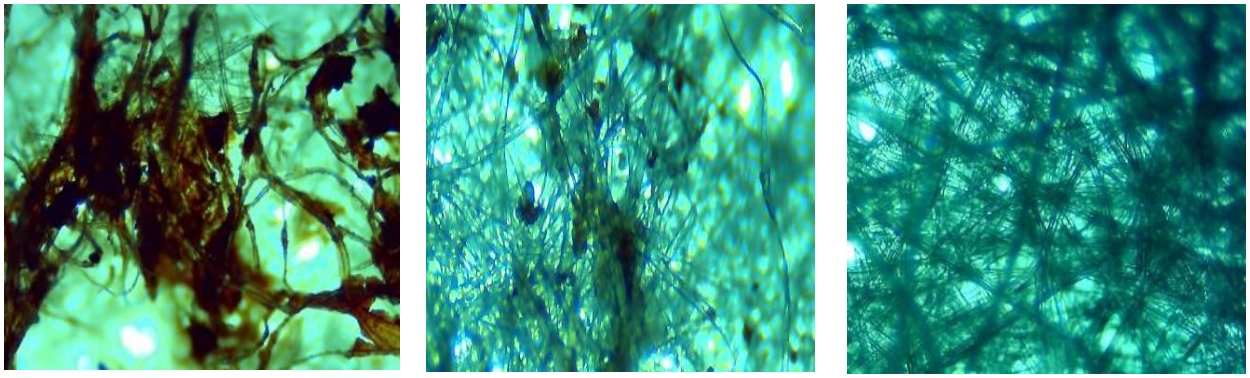


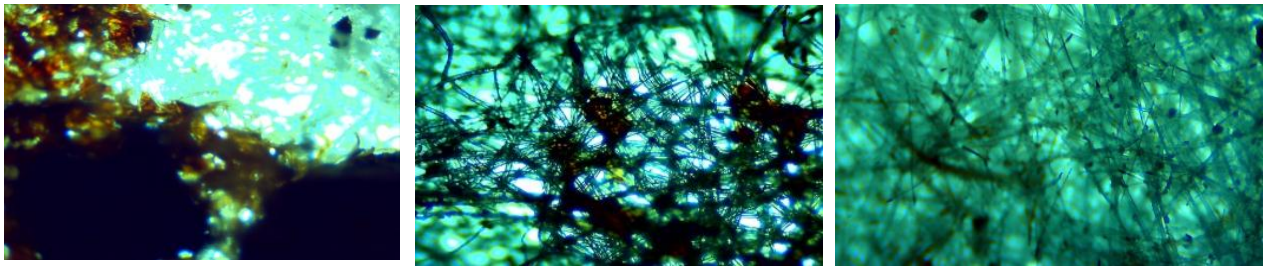
a b c

Fig. 5. Microscopic photographs of the surface of the thinned area of the brown cocoon shell; a) untreated area; b) treated with water for 20 minutes. at 50 ^{0}C; c) treated with Na_2C0_3 solution for 20 minutes. at 50 ^{0}C



a b c

Fig. 6. Microscopic photographs of the surface of the thinned areas of the brown cocoon shell. a) untreated area; b) treated with water for 20 minutes. at 50 ^{0}C; c) treated with Na_2C0_3 solution for 20 minutes. at 50 ^{0}C



a b c

Fig.7. Microscopic photographs of the surface of the thinned area of the black cocoon shell a) untreated area; b) treated with water for 20 minutes. at 50 ^{0}C; c) treated with Na_2C0_3 solution for 20 minutes at 50 ^{0}C.

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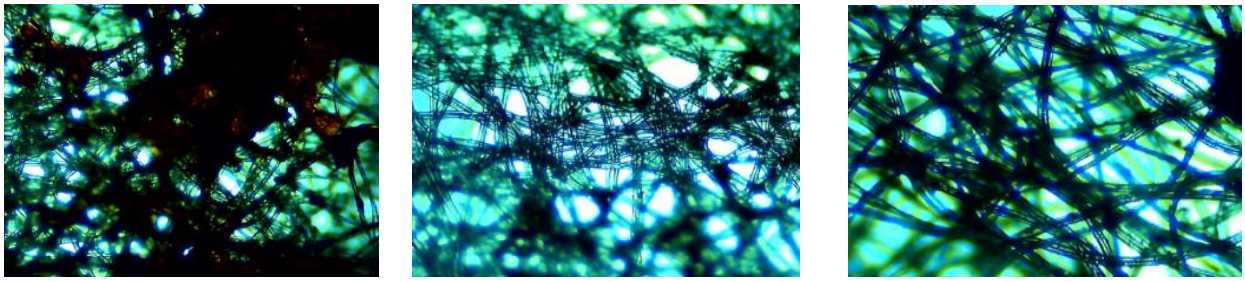

a b c

Fig. 8. Microscopic photographs of the surface of the thinned inner spotted area of the cocoon shell; a) untreated area; b) treated with water for 20 minutes. at 50 ^{0}C; c) treated with Na_2C0_3 solution for 20 minutes. at 50 ^{0}C.

The possibility of processing cocoons with such defects is mainly determined by the interaction of the substance of the spots with water during various types of processing. As a result of the treatment of spotted cocoons in warm water due to the partial dissolution of sedimentary substances, they spread over the surface, as evidenced by a more diffuse structure of the shell in the photographs (Fig. 4-8 b), and with the use of treatment in a soda solution, complete washing out of defective areas is possible (Fig. 4-8 c). Consequently, in the absence of structural destruction of cocoon filaments, it is possible to cleanse the shell structure using surfactants [8].

In the process of steaming the cocoons, the swelling and partial dissolution of sericin occurs. The swelling and dissolution of sericin of varietal cocoons are due to the presence of hydrophilic amino acid residues in this protein and create favorable conditions for the penetration of water into the interfibrillar space. The ease of swelling of sericin in the process of steaming and unwinding is also explained by the fact that the large size of the macromolecule of this protein leads to their not very dense packing, due to which the intermolecular interaction is relatively weak in the case of sericin. In the presence of spots of cocoon shells of the areas, a different picture can be traced. In terms of chemical composition, the excessive content of non-polar amino acids in defective cocoons is much higher than the number of hydrophobic amino acid residues on the spotted areas of the cocoon shell. In addition, the spaces between the individual fibers are quite densely clogged with sedimentary substances, which worsen the penetration of water into the myofibrillar space [9].

In all technological processes associated with the processing of cocoons, the structure of sericin undergoes various changes, and the task is to find optimal conditions that provide a sufficiently fast and uniform swelling of sericin, especially if there are spots on the shell. Without significant changes in the structural ordering of the remaining part of the silk thread protein, high quality silk can only be ensured if the native properties of sericin are preserved in the processes of processing and preparation for unwinding [10].

In this regard, the swelling and rate of dissolution of sericin in cultivated and defective cocoons were investigated depending on the composition of the solvent and temperature.

Good unwinding of cocoons is achieved with uniform swelling of sericin over the layers of cocoons. However, the structural properties of sericin and its amount in the outer and deep layers may differ, and therefore the rate of extraction from different layers may be different. To identify this issue, we studied the rate of extraction of sericin layer by layer [11-12].

In experimental studies, the cocoon shell was divided into separate layers (by weight) and boiled in water for a certain time. After decoction, a comparative analysis of the amount of extracted sericin was carried out over the layers of the shell. The experimental results shown in

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Fig. 9 show that the solubility of sericin decreases with the depth of the shell, and the characteristic rise of the curve during the first 5-10 minutes indicates a slight hydration.

Kinetics of dissolution of sericin from different layers of the cocoon shell on temperature

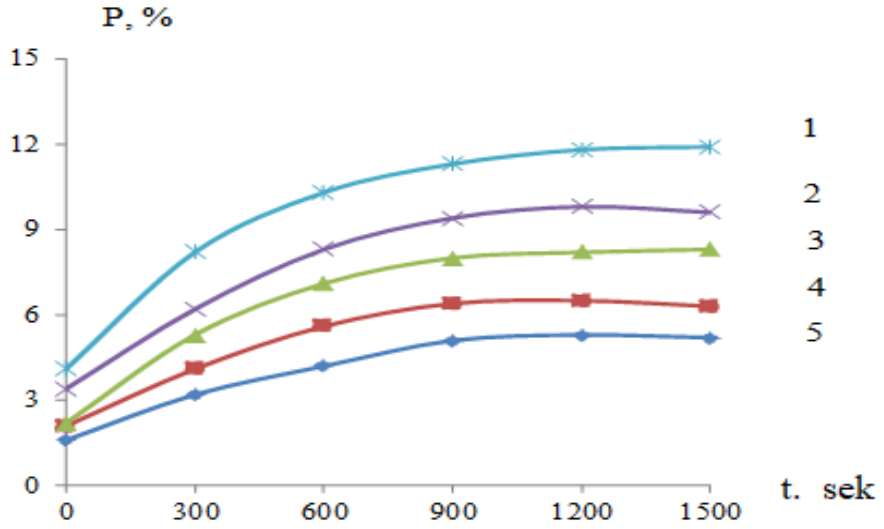

Fig 9. Curves 1-5 refer to the layers, respectively.

Hydrophilic groups of native proteins, especially at elevated temperatures. In this case, we can assume that the dynamics of the removal of sericin from the shell is exponential with a slowdown in time, and the overall rate of extraction decreases with the transition from the outer layers to the inner ones.

In fig. 10 shows the results of a study of the swelling of sericincocones in water at different temperatures. According to the experimental data, the regularity of the increase in the degree of swelling of sericin in clean areas with an increase in the temperature of the technological medium is clearly traced, and, in the range of 50-70 ^{0}C, the sharpest swelling of clean cocoon shells is observed, and the swelling of spotted zones is much slower.

Dependence of the swelling of the cocoon shell on temperature

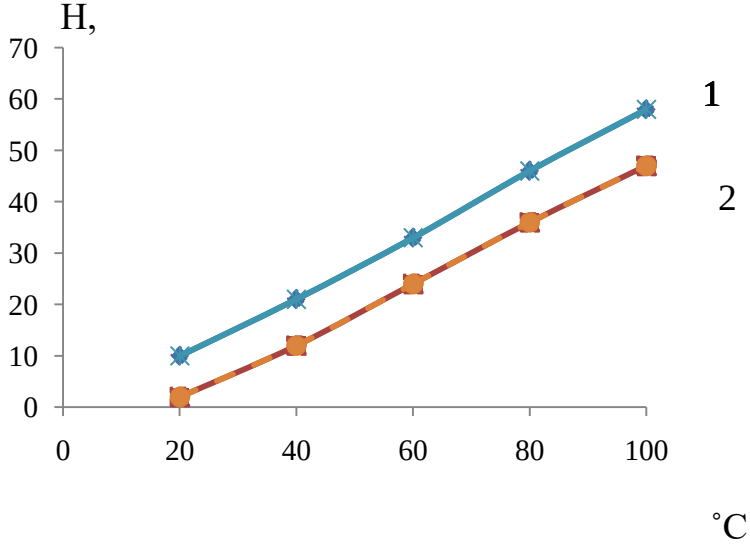

Fig.10 1.Swelling of clean areas; 2.Swelling of spotted areas.

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In order to improve the swelling of the shell of spotted cocoons, various surfactants were used in experimental studies (Fig. 11), (surfactant-1 anionic surfactant, surfactant-2-neonogenic surfactant)

Dependence of the swelling of the spotted zones of the cocoon shell on the concentration of drugs at a temperature of 25 ^{0}C.

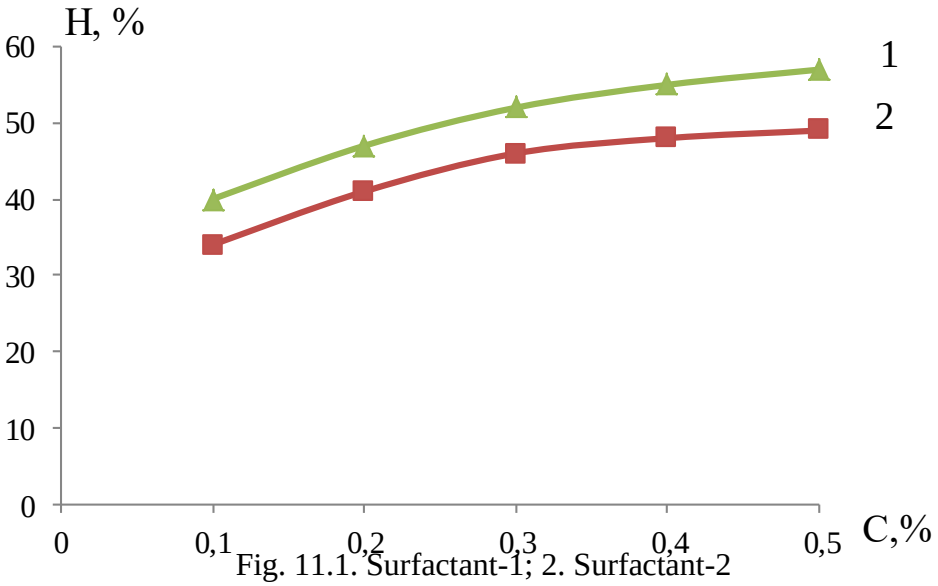

Fig. 11.1. Surfactant-1; 2. Surfactant-2

Moreover, with an increase in concentration, the swelling of the spotted areas also increases and is compared with the swelling of the clean zones at a concentration of 0.2 %.

The dependence of the solubility of sericin on time and on the concentration of the surfactant solution was also investigated. With the addition of preparations - surfactant-1, surfactant-2 to the solution (Fig. 12, 13), the solubility of sericin improves. An increase in the solubility of sericin in the presence of surfactants can be explained by the interaction of charged groups in sericin molecules with the corresponding surfactant ions.

Solubility of sericin from time to time at a drug concentration of 0.1% and a temperature of 25 ^{0}C.

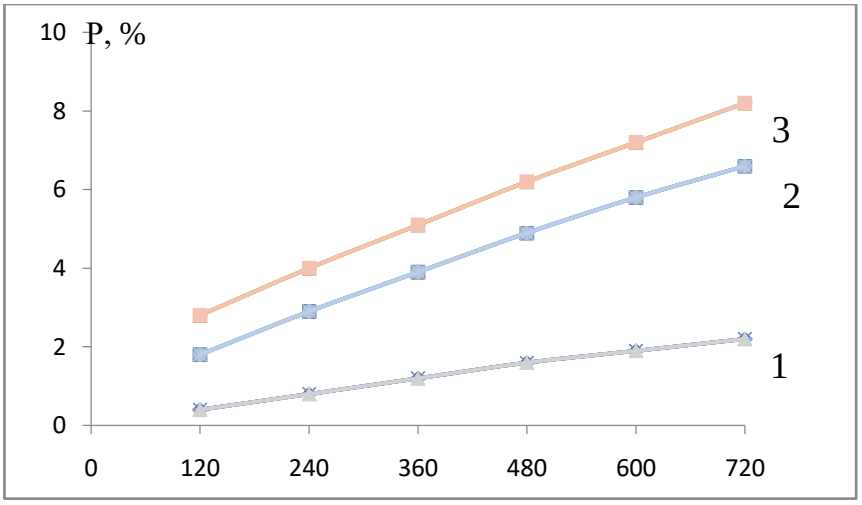

Figure 12. 1. Water; 2. Surfactant-2, 3. Surfactant-1

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Leading to a total decrease in the activity of sericin and, in the presence of spots, facilitating its solubility. At the same time, the indirect effect of surfactants on the structure of water can also contribute to a certain effect.

Solubility of sericin versus temperature at concentration drugs 0.1%.

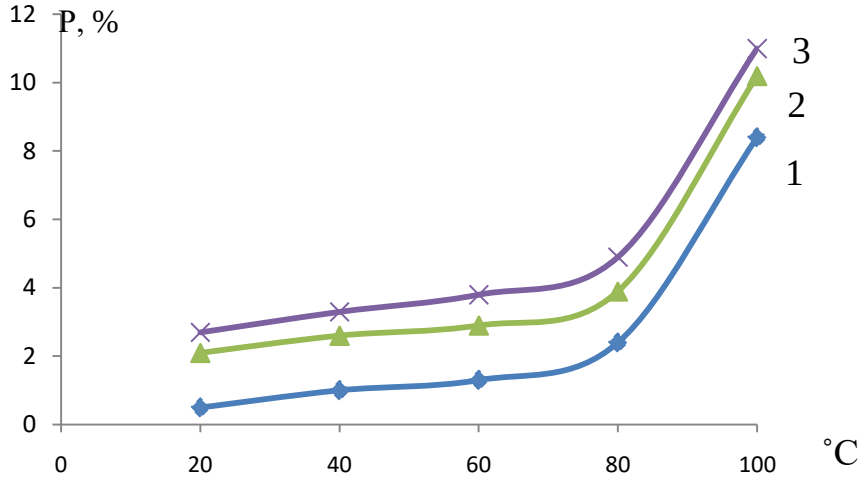

Figure 13. 1. Water; 2.Surfactant-2: 3.Surfactant-1

Experimental data show that by changing the composition of the solvent it is possible to regulate to some extent the processes of softening and the extraction of sericin from the spotty areas of the cocoon shells. The ultimate goal is to limit the degree of dissolution of sericin in spotted areas, and to create favorable conditions for a more uniform swelling of membranes with defects, including spots.

When choosing such conditions, it is necessary to proceed from the data on the effect of various surfactants on the swelling of spotty areas of the cocoon shell and the solubility of sericin.

The given data on the solubility and swelling of sericin in spotted areas for 3-5 minutes at a temperature of 500C and a concentration of 0.4-0.5% show that this mode corresponds to the lowest solubility of sericin and the best swelling.

In addition, the degree of swelling and dissolution of spotty and clean areas of the cocoon shell is leveled; on this basis, it can be assumed that the presence of certain amounts of surfactants contributes to the minimal dissolution of sericin from clean and spotted areas of the cocoon shell and its uniform swelling, which will be favorable for the process of unwinding cocoons.

CONCLUSION

1**.** Microscopic examination of the structure of the areas of the shell of the spotted zones showed that the air spaces between the fibers are clogged with sedimentary substances remaining after the ingress of the liquid fraction of the coloring liquid. The ability of spotted areas to be cleaned of sedimentary substances was checked by preliminary soaking of the samples at a temperature of 50 ^{0}C for 20 minutes in water and a 5% soda solution, it was found that as a result of the treatment of spotted cocoons in warm water due to partial dissolution of sedimentary substances, they are rubbed over the surface , and using treatment in a soda solution, it is possible to completely wash out the defective areas.

2. The treatment of the shell with surfactant solutions promotes a change in the polarity of the contact zone of the surface of the threads with the liquid, thereby changing the surface

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structure, increasing its hydrophilicity, thereby reducing the surface tension and improving the wettability and water permeability.

3. Therefore, in the absence of structural destruction of the conical threads, it is possible to cleanse the shell structure using surfactants.

4. In the presence of certain amounts of surfactants, it promotes minimal dissolution of sericin from clean and spotted areas of the cocoon shell and its uniform swelling, which favorably affects the process of unwinding cocoons.

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