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Theoretical Basis of Drying Recultured Cocoons

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Abstract: Objective. To carry out scientific research on improving the technological properties of cocoon shells grown in repeated seasons and the quality of raw silk, as well as the development of pre-processing technology.

Methods. Killing and drying of cocoons grown in repeated seasons in the existing SK-150K unit in the main cocoon of Jayrakhona Maskan, Termiz District, Surkhandarya Region was carried out. For this purpose, the air temperature of the cocoons grown during the seasons in the SK-150K cocoon killing and drying unit was repeatedly increased from 75°C to 115 °C, every 5°C. During killing process, samples of 40 kg of living cocoons grown in each season were taken and tested until the cocoon temperature reached 37-42 °C.

Results. In this study, when cocoons grown in repeated seasons were killed in the control mode, the first season and second season cocoons in the experiment were not killed by 5-3%, respectively. Experiments were continued by increasing the set mode temperature and reducing it to 45 minutes for the first season cocoons. The temperature in the unit was tested in repeated experiments with every 50°C rise from 75°C to 115°C.

Conclusion. We conclude that the live cocoons loaded into the cocoon drying chamber SK-150K provided with the loading conveyor for loading the cocoons into the drying chamber along the surface of the upper horizontal conveyor for 48 minutes for the cocoons of the first season at a temperature of 110-115°C for the first season, and for the second cocoons of the season are treated at a temperature of 105-110°C for 45 minutes, cocoons of the third season are treated at a temperature of 95-100°C for 40 minutes, and cocoons of the fourth season are treated under the influence of hot air at a temperature of 75-80°C for 35 minutes. The optimal option is to leave it in a completely or partially dry state.

Keywords: Temperature, cocoon, shell, climate, season, drying, hot air, mulberry silkworm.

Introduction. Currently, cocoons are grown in four seasons on the initiative of the Uzbekipaksanoat Association. In order to obtain high-quality raw silk from cocoons grown in recurring seasons, it is necessary to study the technological characteristics of cocoons with the right approach to the processes of preliminary preparation of cocoons and preparation of cocoons. Today, more than 20 countries of the world are engaged in the cultivation of live cocoon raw materials. Our republic is one of the leading countries in the production of cocoons and raw silk. After China, India and Brazil, our republic ranks fourth in cocoon cultivation in the world. The share of raw silk grown in Uzbekistan in the world market is 2,2 percent. One of the main tasks is to increase the number of cocoons grown in our republic, and the production of finished products from them that meet international standards [1-8].

In our republic, certain successes have been achieved in the cultivation and processing of cocoons, the creation of breeds and commercially available hybrids adapted to different regions, as well as high-yielding varieties of mulberry. However, not enough attention has been paid to the development and scientific justification of methods of proper care of domestic and foreign silkworms in the specific arid climatic conditions of Uzbekistan, ensuring their constant temperature and relative humidity. One of the urgent problems of sericulture is conducting scientific research to improve the technological properties of cocoon shells and the quality of raw silk grown in recurring seasons, as well as the development of primary processing technology [9-14]. The primary processing of cocoons is a complex process in which there is an intensive moisture and heat exchange between the drying agent (air), the shell and the pupa. That is why the direct participation of the cocoon shell in the process of moisture loss in the cocoon (drying) requires from it a very careful selection of the pretreatment mode, increased attention to quality preservation. According to the Internet, when drying the cocoon, the hot air drying method is 90%. Most scientists claim that the cocoon as a drying object is a specific (specific) material [15-17]. Moisture in the cocoon is present mainly in the cocoon, and mass transfer during the drying process, including moisture removal, also occurs through the shell. There are a large number of studies in the literature aimed at practical and theoretical study of this process [18-20].

Methods. The results of a case study on the choice of the mode of degreasing and drying of the cocoon. The task of the live cocoon Primary processing bases, one of the most important links of the sericulture industry, is to provide sericulture enterprises with high-quality cocoon raw materials. The main stages of the process of primary processing of a living cocoon are disinfection and drying of its cocoon. Decontamination of a hummingbird prevents it from turning into a butterfly [9]. The drying process, on the other hand, protects the cocoons from damage by mold and shell due to the high humidity contained in them during storage. The primary processing of a living cocoon is a complex process in which there is an intensive moisture exchange and heat exchange between the drying agent, the bark and the cocoon. Therefore, the direct participation of the cocoon shell in the process of decontamination of the cocoon and removal of moisture from its contents requires a study of the primary treatment process based on the laws of thermal engineering, preservation of its technological properties natural through the correct choice of modes and rational use of energy spent on the process. High-quality cocoon production depends on factors such as the breed or hybrid of the silkworm, its feeding conditions, as well as methods of preparation and pre-treatment of grown cocoons.

When choosing the drying mode of cocoons grown in the south of our republic, it is important to determine their initial humidity and the number of cocoons obtained. In the main cocoon shop of the Jairakhan settlement of the Termez district of Surkhandarya region, work was carried out on the existing SK-150K unit to disinfect and dry cocoons grown in recurring seasons. To do this, the air temperature was set from 75^{o}C to 115^{o}C in the SK-150K cocoon disinfection and drying unit, every 5^{o}C was repeated in an elevated position. 40 kg of live cocoons grown during the season during domestication.samples were taken from the cocoon and tested until the temperature reached 37-42 ^{o}C. The test results are shown in Table 1**.**

Table 1.

Options	The temperature mode of killing the fungus, ^{o}C				Duration (min)				Amount of live cocoons that did not die, %			
	1-season	2-season	3-season	4-seas.	1-seas.	2-seas.	3-seas.	4-seas.	1-seas.	2-seas.	3-seas.	4-seas.
Experience	110-115	105-110	95-100	75-80	48	45	40	35	0,03	0,02	0,02	0,01
Control	100-105	100-105	100-105	100-105	55	55	55	55	0,03	0	0	0

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Results. In this study, when cocoons grown in repeated seasons were killed in the control regime, the first season and second season cocoons in the experiment were not killed by 5-3%, respectively. Experiments were continued by increasing the set mode temperature and reducing it to 45 minutes for the first season cocoons. The temperature in the unit was tested in repeated experiments with every 50 °C rise from 75 °C to 115°C. In the experiment, it was observed that 2.8% of mushrooms were not killed at 105-110 °C when the first season cocoon killing time was reduced to 48 minutes. In this study, when cocoons grown in repeated seasons were killed in the control regime, the first season and second season cocoons in the experiment were not killed by 5-3%, respectively. Experiments were continued by increasing the set mode temperature and reducing it to 45 minutes for the first season cocoons. The temperature in the unit was tested in repeated experiments with every 50 °C rise from 75 °C to 115 °C. In the experiment, it was observed that 2.8% of mushrooms were not killed at 105-110 °C when the first season cocoon killing time was reduced to 48 minutes. When the temperature rises to 95-100 °C, complete inactivation of the fungi is achieved. Air temperatures for fourth season cocoons were tested in replicate experiments ranging from 45-50 °C to 75-80 °C with each 5 °C increase. Based on the climatic conditions of the cocoons grown in repeated seasons, taking into account the fact that the cocoons are not wrapped well, the shell is thin, and the number of small-caliber cocoons is large, testing and control work was carried out for 25, 30, 35, 40 minutes. When the results of the experiment were shortened to 30 minutes, it was observed that 2.2% of fungi were not killed at 70-75 °C. When the temperature increased to 75-80 °C, complete inactivation of the fungi was achieved. From the conducted research, we conclude that live cocoons loaded into the cocoon drying chamber SK-150K provided with a loading conveyor for loading the cocoons into the drying chamber along the surface of the upper horizontal conveyor, 110-115 °C for 48 minutes for the first season cocoons at temperature, for cocoons of the second season for 45 minutes at a temperature of 105-110 °C, for cocoons of the third season at a temperature of 95-100 °C for 40 minutes, for cocoons of the fourth season for 35 minutes under the influence of hot air at a temperature of 75-80 °C, processed cocoons on the lower conveyor The optimal option is that the mushrooms become lifeless and come out in a completely or partially dry state.

Cocoon and its components sponge, experimental variations of humidity of shells with time and their nonlinear regression equations. The following information is required to construct the regression equation. a) the experimental values of the connection between the input and output parameters are given in the form of a table; b) the analytical form of the regression equation is selected; c) the level of significance of the equation is evaluated in value; g) the relationship between variables is evaluated by the correlation coefficient. Table 2 shows the experimental values of the moisture content of the shell product over time.

Table 2. Variation of cocoon moisture (y, %) over time (t, min.).

t (min)	0	15	30	45	60	75	90	105	120	135
y (%)	185	170	135	110	88	76	63	48	44	41

The drying process of the cocoon decreases exponentially with time according to the works of. Taking this rule into account, we get the regression equation in this form over time.

$$y = \exp(a + bt) \qquad (1)$$

If we logarithmize this expression

$$z = \ln(y) = a_1 + b_y t$$

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Thus, $z = z(t)$ is a linear function, its coefficients a and b are determined by the method of having the smallest value of the square deviation.

$$b_y = \frac{n\sum_{i=1}^{n} t_i y_i - \sum_{i=1}^{n} t_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i\right)^2}, \quad a_1 = \frac{\sum_{i=1}^{n} t_i^2 \sum_{i=1}^{n} y_i - \sum_{i=1}^{n} t_i \sum_{i=1}^{n} t_i y_i}{n\sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i\right)^2}, \qquad (2)$$

(2) using Table 1 in the formulas, we get the results by putting the numerical values of n=11, t_i and y_i.

$$b_y = -0.01158 \; , \; a_1 = 5.2217$$

To determine the regression coefficient, $u = \ln(t) = a_2 + b_t y$ we use Eq. Here, b_x and a_2 are calculated using the formulas below.

$$b_t = \frac{n\sum_{i=1}^{n} t_i y_i - \sum_{i=1}^{n} t_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}, \quad a_2 = \frac{\sum_{i=1}^{n} y_i^2 \sum_{i=1}^{n} t_i - \sum_{i=1}^{n} y_i \sum_{i=1}^{n} t_i y_i}{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}$$

If we use the values in the table

$$b_t = -0.85079 \; , a_2 = 445.43$$

The correlation coefficient will be equal to this value

$$r = \sqrt{|b_y||b_t|} = 0.9921$$

Let's calculate these statistics

$$t_c = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} = 23.8$$

According to Student's criterion (in the table), the selected regression link is appropriate because the condition $t_{1-\alpha;k} = t_{0.95,n-2} = t_{0.95.9} = 2.23$ $t_c > t_{0.95.9}$. is fulfilled. Thus the regression equation

$$y = \exp(5.2217 - 0.01158t) \qquad (3)$$

is taken in appearance

Figure 1 shows the experimental and regression lines with lines 1 and 2

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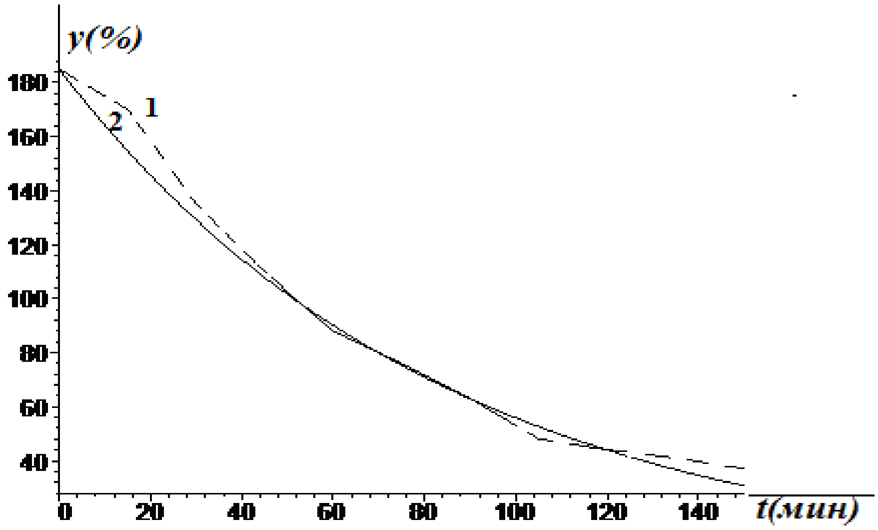

Figure 1. Drying lines of the cocoon in experimental (1) and regression binding (2).

Using the above method, regression equations and their correlation coefficients for sponges and shells are presented in Tables 3 and 4, as well as Student's criterion for assessing the validity of the existing association.

Table 3. Variation of pupa moisture (y, %) with time (t, min)

t (min)	0	15	30	45	60	75	90	105	120	135
y (%)	330	290	240	210	180	140	110	80	70	60

The regression equation $y = \exp(3.679 - 0.01392t)$ (4)

Since the statistic $t_c = 25.52$, $t_c > t_{0.95.9}$. is performed, the regression link is appropriate. Regression coefficient $r = 0.9931$

In Figure 2, lines 1 and 2 show the experimental and regression lines of mushroom moisture over time.

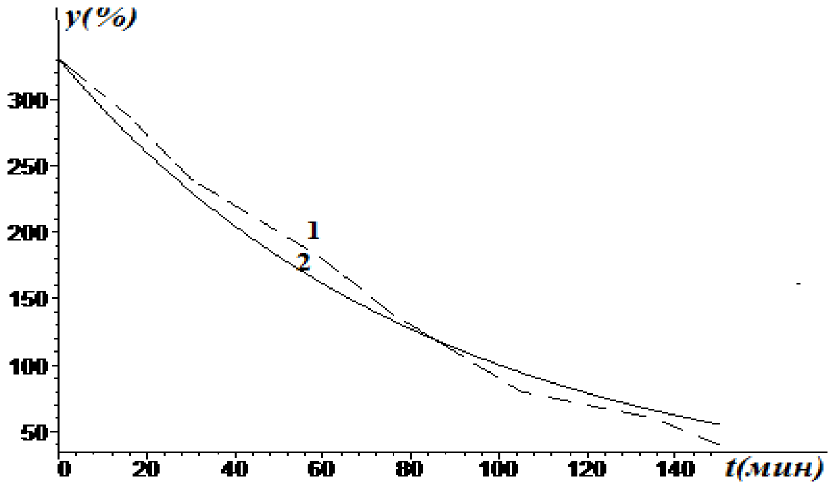

Figure 2. Drying lines of sponge in experimental (1) and regression link (2)

Table 4. Changes in shell moisture (y,%) over time (t, min).

t (min)	0	15	30	45	60	75	90	105	120	135
y (%)	360	280	150	100	55	51	50	47	46	44

The regression equation $y = \exp(5.436t - 0.0142t)$ (5)

Since the statistic $t_c = 5.6687$, $t_c > t_{0.95.9}$. is met, the regression link is appropriate. Regression coefficient $r = 0.8838$. In Figure 2.3, lines 1 and 2 show experimental and regression lines of mushroom moisture over time.

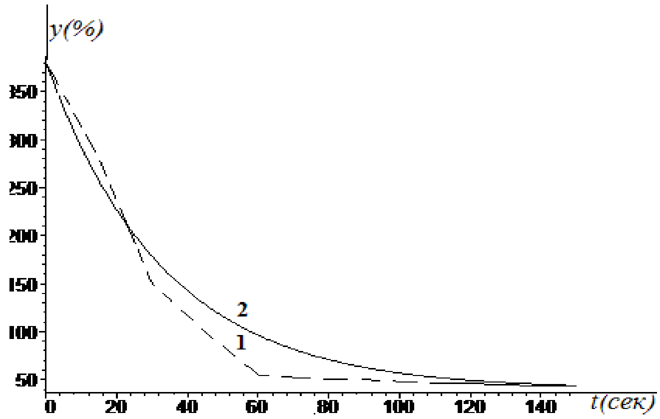

Figure 3. Drying lines of the shell in the experimental (1) and regression connection (2).

Figures 1-3 show experimental (line 1) and regression lines of humidity in the cocoon (Figure 1) and its components shell (Figure 2) and dome, and their appropriateness is evaluated by the criteria. Experimental results are taken from work from their study, it is observed that the regression relationship in the form (1) is in sufficient agreement with the experimental results according to the criteria. In this case, the appropriateness of the connection can be brought out theoretically. For this, we use the drying equations presented in the works regarding the cocoon and its components

$$\frac{dW_i}{dt} = -K_i(W_i - W_{ip}) \ (i = 1,2.3) \qquad (6)$$

Here, W_1, W_2, W_3 are moisture content of the cocoon, shell and cone, respectively, their drying coefficients (K_i) and equilibrium moisture content (W_{ip}), which are experimentally determined by K_i and W_{ip} ($i = 1,2.3$) of the following equations $W_i(0) = W_{i0}$ the solutions in the condition will be as follows

$$W_i = W_{ip} + (W_{i0} - W_{ip})\exp(-K_i t) \qquad (7)$$

Figures 4-6 (a) show graphs of changes (drying lines) of cocoon, shell and sponge moisture content over time. Regression (formulas 3-5) are shown in black, and theoretical lines based on formulas (7) are shown in red. In accounts $W_{1з} = 0.1\%$, $W_{10} = 185\%$, $K_1 = 0.012\,(1/\min)$, $W_{2p} = 0.1\%$, $W_{20} = 330\%$, $K_2 = 0.012\,(1/\min)$, $W_{3з} = 0.1\%$, $W_{30} = 380\%$, $K_3 = 0.03(1/\min)$ accepted.

Experimental (regression) lines from graph analysis may differ from each other by 1-15%.

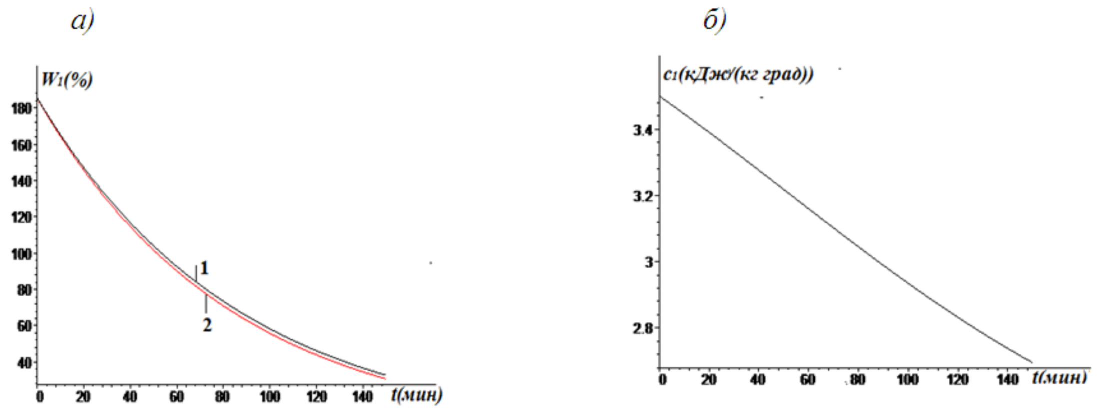

Figure 4. Experimental (1) and theoretical (2) drying curves of cocoon $c_i(\mathrm{kDj}/(kg\ grad)$ (a) and graph of specific heat capacity change over time $t(\mathrm{min})$ change graph over time (b)

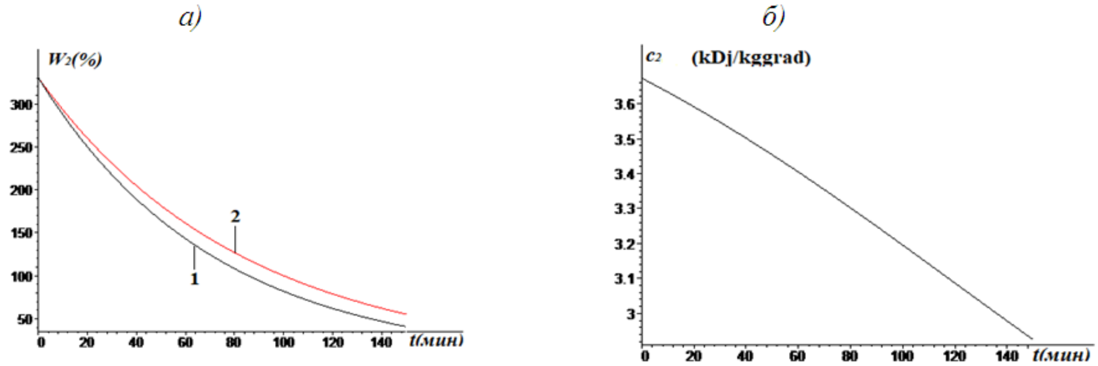

Figure 5. Experimental (1) and theoretical (2) drying lines of the shell (a) and the change graph of specific heat capacity $c_i(\mathrm{kDj}/(kg\ grad)$ over time $t(\mathrm{min})$ (b)

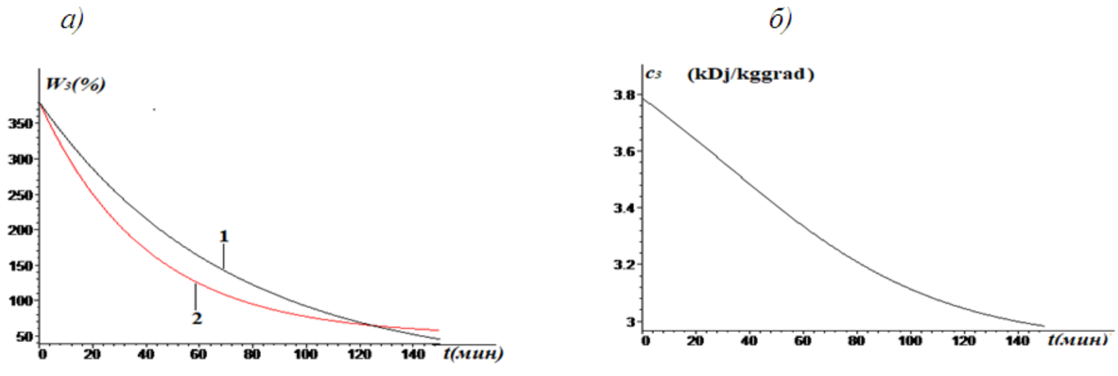

Figure 6. Experimental (1) and theoretical (2) drying curves of the sponge (a) and the change graph of specific heat capacity $c_i(\mathrm{kDj}/(kg\ grad)$ time $t(\mathrm{min})$ (b)

(7) using the formulas proposed in, it is possible to determine the time variation of the relative heat capacities of the cocoon ($c_i(\mathrm{kDj}/(kg\ grad)$), the shell

($c_i(\mathrm{kDj}/(kg\ grad)$) and the dome

$$c_i = c_{i0} + (4.18 - c_{i0})\frac{W_i(t)}{W_i(t)+100} \quad (i = 1,2.3) \qquad (8)$$

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Here, c_{i0} is the relative heat capacity of the cocoon $(i=1)$, the shell $(i=2)$ and the dome $(i=3)$ in the absolute dry state. The graphs of specific heat capacity c_i change over time are presented in figures (2.7) (b). In accounts $c_1 = 2.24$ $c_i(\text{kDj}/(kg\ grad)$, $c_2 = 2.29$ $c_i(\text{kDj}/(kg\ grad)$, $c_3 = 2$ $c_i(\text{kDj}/(kg\ grad)$ accepted.

(8) determining the average value of moisture and specific heat capacities for the system consisting of cocoon + shell + pupa using the formula, it will be possible to determine these parameters for the cocoon aggregate.

$W_c = (h_1W_1 + h_2W_2 + h_3W_3)/h$, $c_{cp} = c_{po} + (4.18 - c_{po})W_c/(W_c + 100)$

Figure 7 shows the graphs of aggregate moisture and specific heat capacity over time

a) б)

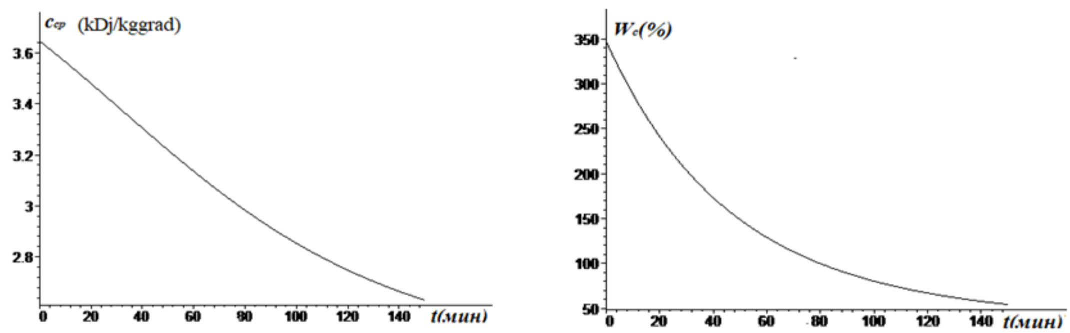

Figure 7. The drying line of the unit (a) and the change graph of specific heat capacity $c_i(\text{kDj}/(kg\ grad)$ **over time** t(min) **(b)**

Conclusion.

It was found that the cultivation of a high-quality cocoon depends on factors such as the breed or hybrid of the silkworm, its feeding conditions, as well as methods of preparation and pretreatment of grown cocoons. The experiments were carried out on existing SK-150K cocoons in a lifeless and drying plant with samples of cocoons grown during the seasons. The optimal options for the technological operation of the unit were determined in such a way that the crumbs of cocoons grown in seasons become lifeless and come out in a state of complete or partial drying. A pretreatment regime has been developed for cocoons grown during recurring seasons. When choosing the cocoon drying mode, the results of a practical study were obtained. Cocoons and their components were formed by hummingbirds, experimental changes in the moisture content of the shells over time and their nonlinear regression equations. A theoretical study was conducted of the change in the temperature given to the cocoon over time and the decrease in humidity.

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