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Study Of Heat-Physical Processes In Solar Dryers

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ABSTRACT: This article raises the problem of studying the thermal and physical processes that take place in solar fruit dryers. Technological processes related to the quality of dried fruits in dryers were studied.
KEY WORDS: solar dryer, heat-physical process, construction mode, fruit quality, construction kinetics

1. INTRODUCTION

The development of effective solar fruit dryers and its implementation requires the study of heat-mass exchange, thermal-physical processes that occur during the drying of fruits. Determining the construction mode of each fruit dried in dryers, the study of construction kinetics, technological processes related to the quality of dried fruits is one of the current tasks. Technological, thermal and other characteristics of dried fruits should be taken into account when choosing the optimal mode of drying fruits. It is also necessary to know the physicochemical, structural, optical and many other properties of fruits in the development of an effective technological process of drying.

Analysis
During the construction process, the fruits are exposed to solar radiation, which changes their temperature, humidity, shape and other properties. This leads to a change in the thermoradiation and optical characteristics of the fruit. These characteristics are the main criteria for determining the quality indicators of the fruit [3 p. 76]. A spectrocalorimeter operating in the visible and near-infrared regions of the spectrum (380–1100 nm) was used to determine the optical and thermoradiation characteristics of the fruits.

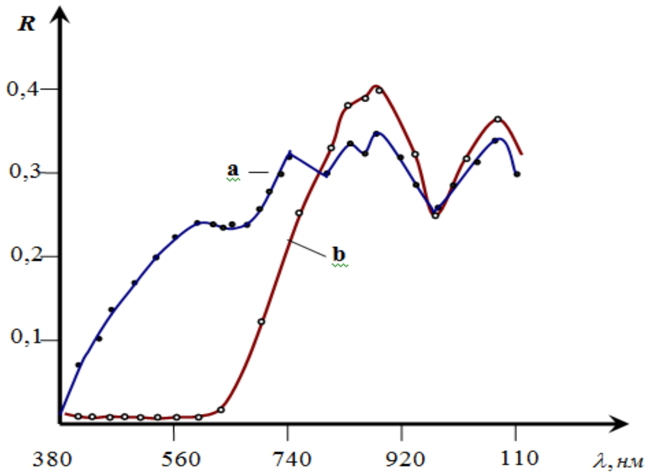

Figure 1. Dependence of the spectral reflection coefficient of mulberry fruit on the light wavelength

(fruit moisture 81%). a – white mulberry, b - mulberry.

A study of a mulberry and apricot by spectrocalorimeter operating has revealed the following. The return spectrum of freshly cut white and mulberry fruit differs sharply from each other in shape and intensity (Figure 1). As can be seen from the graph, mulberry fruit reaches its maximum value $\lambda = 740nm$ at the return coefficient. At the same time, the maximum return coefficient for the mulberry corresponds $\lambda = 880nm$ to the wavelength. For the mulberry fruit, the return coefficient $\lambda = 380nm - 670nm$ in the spectral region is very small, close to zero. In the spectral range $\lambda = 670nm - 900nm$ the return coefficient increases sharply to 0.31. This is explained by the fact that it depends on the color of the mulberry fruit. However, the curvature $\lambda = 740nm$ of the optical and thermoradiation characteristics in the spectral region is almost the same for different varieties of mulberry fruits [2 p. 51].

Along with mulberry, the optical and thermoradiation characteristics of apricots were also studied. The characteristic absorption pathways for the tested samples $\lambda = 660nm$ and $\lambda = 990nm$ correspond to the wavelengths. The optical and thermoradiation characteristics $\lambda = 380nm - 500nm$ for fresh and dried apricots are very small, with a reflection coefficient in the spectral field of 3… 7%. $\lambda = 520nm - 580nm$ in the wavelength field, the return coefficient increases sharply to a value of R = 0.45. Once the apricot is dry, its shape of its return spectrum changes, thereby losing the absorption pathways (Figure 2).

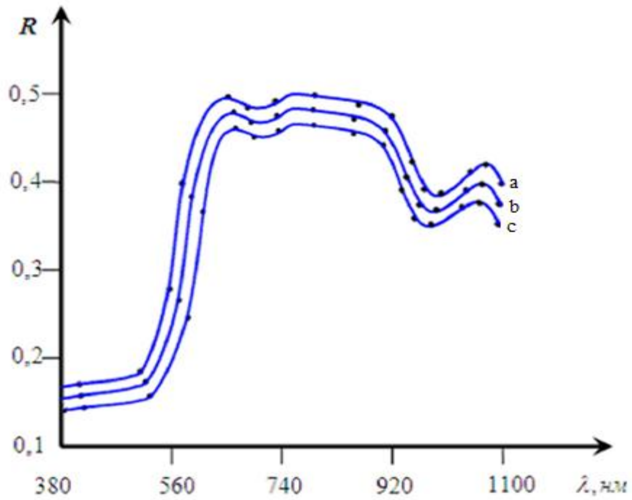

Figure 2. Dependence of spectral-thermoradiation characteristics of apricots on light wavelength

(a- Sogdian apricots, b - ordinary apricots, c- hairless apricots)

Thus, a proper study of the samples shows that the optical and thermoradiation characteristics of different fruits depend not only on their internal structure, but also on their color and fruit shape. The results obtained on the optical and thermoradiation characteristics of mulberry and apricot allow to determine the quality of the dried product and to carry out appropriate calculations for the design of solar dryers.

2. DISCUSSION

In developing a mathematical model of the physical processes that take place during the drying of fruits in the dryer, we used the following assumptions:
1. The temperature is the same at all points in the drying chamber.
2. The pressure inside the dryer is $P = P_A$ equal to the outside atmospheric pressure.
3. The pressure inside the dryer does not depend on the temperature, as the thermal and physical parameters of the air and the dried fruit do not change. Also, the difference between the fruit temperature and the air temperature in the chamber is not taken into account in the modeling. Suppose the dryer enters. Regardless of the air flow rate G^+ and the air flow rate G_-, the air mass balance in the dryer is written as follows:

$$\frac{Vd\rho}{d\tau} = -\frac{dM}{d\tau} + G_+ - G_- \quad (1)$$

The following equation can be written for the vapor concentration inside the chamber [1 p. 70], [4 p. 81], [6 p. 26], [9 p. 11].

$$V\rho\frac{dC}{d\tau} = -\frac{dM}{d\tau} + G_0 - G_+ \quad (2)$$

Considering (2), (1) can be written as follows:

$$V\rho\frac{dC}{d\tau} = -\frac{dM}{d\tau}(1-C) - G_-(C - C_0) \quad (3)$$

As mentioned above, $P > P_A$ since the gas state equation we write the following:

$$P = \rho RT\left\{\frac{C}{\mu_\delta} + \frac{1-C}{\mu_8}\right\};\ P_a = \rho_a RT\left\{\frac{C_a}{\mu_\delta} + \frac{1-C_a}{\mu_8}\right\}$$

$$\rho T\left(\frac{C}{\mu} + \frac{1-C}{\mu}\right) = \rho_a T_A\left(\frac{C_a}{\mu_\delta} + \frac{1-C_a}{\mu_8}\right)$$

we enter the definition as follows:

$$C_P = \frac{KR}{K-1}\left(\frac{C}{\mu_\delta} + \frac{1-C}{\mu_8}\right);C_{P_a} = \frac{KR}{K-1}\left\{\frac{C_a}{\mu_\delta} + \frac{1-C_a}{\mu_8}\right\}$$

$$C_P\rho T = C_{\rho_a}\rho_a T_a \quad (4)$$

Now we derive the energy equation [11], [14 p. 51]. The airflow entering the dryer $G_+ C_P T_a d\tau$ carries heat energy. The energy emitted from the camera is equal to $G\_C_P dT\tau$.

In addition, solar radiation is the main factor influencing the change in chamber temperature, and its share is equal to $AJSd\tau$. There will be an amount of heat transferred to the outside environment due to heat exchange $Q = \alpha F(T - T_a)d\tau$ бўлади.

So,

$$\frac{dC_P \rho TV}{d\tau} = C_P G_+ T_a - C_P G_- T + JAS + \alpha F(T_A - T) \qquad (5)$$

But $C_P \rho TV = PV \frac{K}{K-1} = const$ because of

$$C_{P_a} G_+ T_a - C_P G_- T + AJS + \alpha F(T_a - T) = 0$$

$$G_- = \frac{C_{P_a} G_+ T_a + JAS + \alpha F(T_a - T)}{C_P T} \qquad (6)$$

To close the system of equations, it is necessary to determine the amount of moisture that evaporates from the dried fruit.

In developing such a model, we use the following assumptions. First, the transfer of heat from the fruit to the external environment occurs due to moisture exchange (evaporation).

The second is the diffusion coefficient of moisture migration in the fruit (its diffusion) D and thickness λ occurs through the fruit peel. According to the first hypothesis, the flow of the wet mass is equal to $j = \frac{q}{r}$. The diffusion coefficient is $D = \frac{\lambda}{C_P \rho}$

(7)

Here, λ_1 and ρ the thermal conductivity and density of the fruit accordingly. According to Fure's law, the heat flux density is determined from the following formula.

$$q = \lambda \frac{dT}{dn} \qquad (8)$$

(8) given the expression, the flow density of the wet mass can be written as follows:

$$j = \frac{C_P S}{r} D \frac{dT}{dn} \qquad (9)$$

Using the ratio of the temperature gradient to the density gradient at the boundary of the fruit peel, we write the following expression: $\frac{dT}{dn} = \frac{T}{\rho}\frac{d\rho}{dn}$

So, wet flow density

$$j = \frac{C_P T}{r} D \frac{\Delta\rho}{\lambda}$$ $dn \approx \lambda$ equality is taken into account.

$\lambda -$ the thickness of the fruit skin.

The vapor density on the inner surface of the fruit is equal to the saturated vapor density at a given temperature.

$$\Delta\rho = \rho_c(T) - \rho_\delta$$

Thus the density of the wet stream coming out of the surface of the fruit can be written as follows:

$$j = \frac{C_P TD}{r\lambda}(\rho_S(T) - \rho_\delta) \qquad (10)$$

Thus $\rho_S(T)$ - the density of saturated vapor is determined from the equation of ideal gas state.

$$\rho_S(T) = 610{,}8 \cdot 10^{8{,}615}\frac{T-273}{T} \quad (11)$$

$$\frac{dM}{d\tau} = \frac{C_P TD}{r\lambda} S_M \left[\rho_S(T) - C_\rho\right] \quad (12)$$

Thus S_M - the surface of the fruit means that we have created a system of closed equations. In order to solve the obtained equations numerically, it is necessary to make them dimensionless. The temperature for this $T = 300K$ to normal temperature ρ density $\rho = 1{,}25\frac{kg}{m^2}$, time $\tau_0 = 24hour$ heat capacity $\frac{K}{\mu}$ we get the ratio of the mass of fruit to $\rho_0 V$ [7 p. 146].

As a result, the equation comes to the following dimensionless equation.

$$\frac{d\tilde{\rho}}{d\tilde{\tau}} = -\frac{d\tilde{M}}{d\tilde{\tau}} + \tilde{G}_+ - \tilde{G}_-$$

$$\rho\frac{d\tilde{C}}{d\tilde{\tau}} = \frac{d\tilde{M}}{d\tilde{\tau}}(1-C) - G_+(C - C_a)$$

$$G_- = \frac{C_{+a}G + T_a + \tilde{J} + \alpha(T_a - T)}{\tilde{C}_P T} \bar{T}\tilde{\rho}\tilde{C}_P = \tilde{C}_P\tilde{\rho} = \bar{T}_a$$

$$\frac{dM}{d\tau} = D(\rho_S - C\tilde{\rho}) \quad \tilde{M} = \frac{M}{\rho_0 V} : \ \tilde{G}_+ = \frac{G_+\tau}{\rho_0 V}$$

$$J_{нур} = \frac{J_{нур}\tau\mu_b S}{\rho_0 RVT_0}; \quad \alpha = \frac{\alpha\tau\mu_b F}{\rho_0 VR}; \quad D = \frac{DS\tau RT_0}{V\lambda r}$$

$$\tilde{G}_- = G_-\frac{\tau}{\rho_0 V}; \ \tilde{G}_{Pa} = \frac{K}{K-1}(1 - C_a + C_a\frac{\mu_x}{\mu_\delta})$$

$$\tilde{C}_P = \frac{K}{K-1}\left(1 - C + C_a\frac{\mu_b}{\mu_\Pi}\right)$$

Numerical results are obtained at the following values of quantities. $V = 12м^3; \ C_a = 0{,}007 \quad S = 10м^2 \quad F = 16м^2$

$$S = 3{,}5м^2 \quad r = 2{,}5\cdot 10^5\frac{Ж}{кг} \quad L = 5\cdot 10^{-5}м; \quad \alpha = 8\frac{BT}{м^2к}$$

Experiments show that the diffusion coefficient of the fruit peel depends on the type of fruit and its moisture content. In this study, the following empirical formula was used to calculate the diffusion coefficient.

$$D = D_0 e\left(\frac{W}{W_0} - 1\right) \quad (13)$$

Thus $\beta -$ coefficient depending on the type of fruit $D_0 -$ the coefficient is the diffusion coefficient of the fruit before drying.

The following interpolation expressions can be used to determine the ambient temperature

$$J_{нур} = \frac{1}{6}\left[J_1(\tau - 6) + J_0(14 - \tau)\right]$$

$$T_a = \frac{1}{8}\left[T_1(\tau - 8) + T_0(14 - \tau)\right]$$

$$J_{нур} = \frac{1}{4}\left[J_2(\tau - 8) + J_1(18 - \tau)\right]$$

$$T_a = \frac{1}{4}\left[T_1(\tau - 14) + T_1(18 - \tau)\right]$$

$$J_{нур} = \frac{1}{6}\left[J_0(\tau - 14) + J_2(24 - \tau)\right]$$

$$T_a = \frac{1}{6}\left[T_1(\tau - 18) + T_2(24 - \tau)\right]$$

Thus $J_0 = 50\frac{W}{m^2}$ $J_1 = 750\frac{W}{m^2}$ $J_2 = 250\frac{W}{m^2}$ $T_0 = 293\frac{W}{m^2}$ $T_1 = 308K$ $T_2 = 303$

In the above formulas, time is measured in hours, and the beginning of the calculation of time is assumed to be at 6 o'clock in the morning.

Which enters the dryer in the system of equations given $G_+ -$ air consumption is unknown $G_+ -$ since air consumption depends on many factors, it is much more difficult to find by calculation [5 p. 44], [10 p. 148].

Therefore, we use its value determined $(G_+ = 100)$ experimentally.

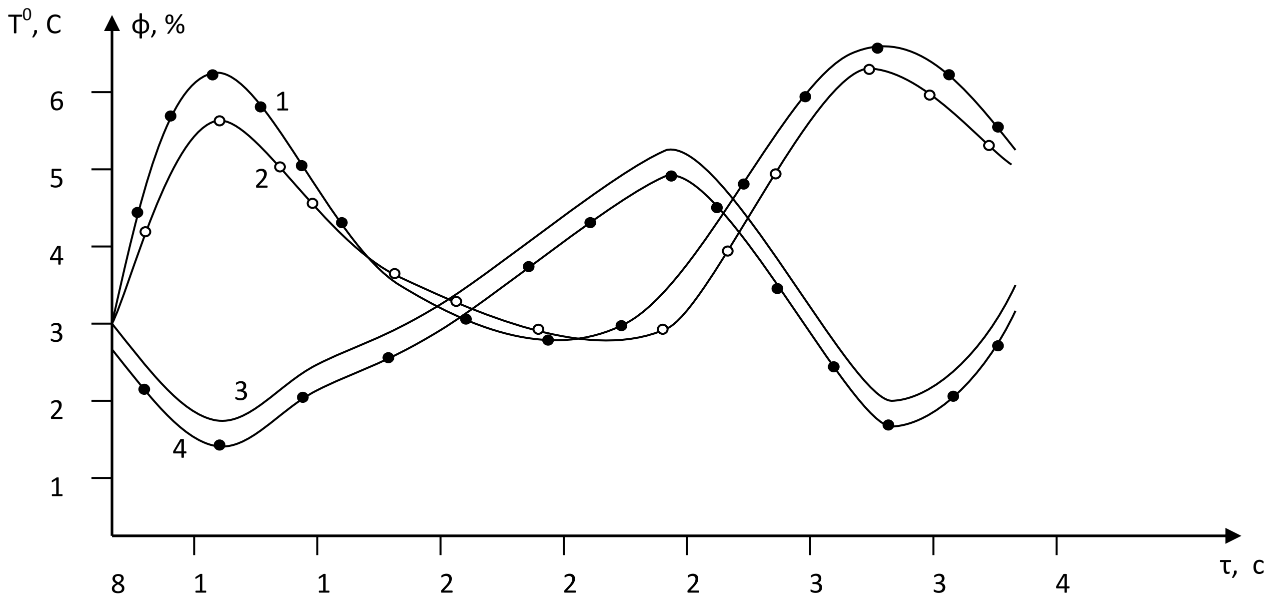

Figure 3. Daily change in temperature and relative humidity of the air inside the dryer

Artificial ventilation is also modeled in the numerical solution of a system of equations. If the relative humidity inside the dryer $(\varphi = 30\%)$ exceeds the allowable value ventilation is

switched on. In this case, this will increase until the humidity increases $G_{+}-$. In the numerical solution of the system of equations, Euler's finite-disclosure scheme was used. In this case, the dimensionless step is in time taken to be equal to $d\tau = \frac{1}{1440}$. The error of the performed calculations does not exceed 0.1%. Figure 3 shows the relative change in relative humidity and temperature inside the dryer as a result of a comparison of the experimental results with the results calculated in the model to assess the accuracy of the mathematical model that reflects the drying process of the fruits in the dryer [8 p. 178], [12 p. 2669], [8 p. 14375].
One way to increase energy (heat - efficiency) efficiency in all dryers is to reduce the amount of heat lost from the device.

3. CONCLUSION

Fruits and vegetables grown in our country are distinguished by their unique taste. Therefore, the similarity of dried fruits and dried vegetables made from them is not found in the world market. Therefore, such products are in great demand in the world market.

REFERENCES

[1] Nazarov M.R., Komilov O.S., Shadyev S.F., Kakharov S.K. A combined solar dryer-greenhouse with a heat accumulator// Geliotekhnika. – Tashkent, 1993. № (2), – P. 70–72
[2] Nazarov M.R., Komilov O.S., Kakharov S.K., Shadiev S.F. Influence of preliminary infrared treatment on process of drying fruits//– Tashkent, Geliotekhnika. 1994, № (3), – P. 49–51.
[3] Nazarov M.R., Kakharov S.K., Nuriddinov Kh., Khaitov R.A. Investigation of thermophysical characteristics of mulberries// Applied Solar Energy (English translation of Geliotekhnika). – Tashkent, 1996. №32(2). – P. 75–76.
[4] Qahhorov S.Q., Samiev K.A., Jo'raev H.O. Process modeling in solar devices. Monograph. - Tashkent. ITAPRESS, 2014. - 208 p.
[5] Juraev Kh.O., Khamdamova N.M. Using alternative energy sources in education // Modern humanitarian research. – Moscow, 2015. №3. – P. 42–48.
[6] Каххоров С.К., Жураев Х.О., Жамилов Ю.Ю. Рециркуляционная солнечная сушильная установка // Наука и мир. – Волгоград, 2016. № 11 (39). – С. 26–28.
[7] Kahharov S.K., Juraev Kh.O. Alternative energy sources// Textbook. Tashkent. Niso print house, 2016. –P. 214.
[8] Juraev Kh. Ways of using educational materials on alternative energy sources at natural lessons// European science review. – Austria, 2018. № 1-2. –P. 177-180.
[9] Qahhorov S.Q., Juraev H.O. Modeling of heat-physical processes in
[10] solar dryers//Journal of Critical reviews. –Kuala Lumpur, 2020. № 7. – P. 9–15.
[11] Kahhorov S.K., Juraev Kh.O. Use of alternative energy sources at the natural sciences lessons // The Way of Science. 2017. №2 (36).–P. 148-150.
[12] Kakhkharov S.K., Nazarov M.R., Juraev H.O. Kakhkharov O.S. “Combined solar dryer” Patent for invention No.IAP 05746. 2018.
[13] Khamdamova N.M. Use Of Alternative Energy Sources In Explaning Materials On Interdisciplinary Integration To Students// International Journal of Future Generation Communication and Networking. – Australia. 2020. №4, Vol. 13. –P. 2667- 2672.

[14] Khamdamova N.M. Develoment of student technical entrepreneurship with the use of alternative energy sources// Palarch's Journal Of Archaeology Of Egypt/Egyptology. – Hannover, Germany. 2020. № 17(6). –P. 14374-14384.
[15] Каххоров С.К., Жураев Х.О. Исследования теплофизических параметров в солнечно-сушильных установках // Наука и мир. – Волгоград, 2016. №7 (35). – С. 50–54.