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EXPERIMENTAL STUDY OF DRIED TO OPTIMIZE AND OBTAIN A PRODUCT WITH NEW PROPERTIES

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Abstract. *In the work analyzes the process of drying of food products in order to obtain experimental results of heat distribution studies in the dried product. Results on the optimization of energy consumption during drying by the use of a discrete (intermittent) drying. Inulin distribution curves are presented for the Jerusalem artichoke with a specific layer. An essential element of the separation of inulin in layers. Presented received the analytical results of applied research with the help of mathematical physics methods.*

Key words: drying, distribution of trace elements, infrared heating, inulin.

INTRODUCTION

Vegetable drying process is based on the fact that infrared radiation of a specific wavelength is absorbed by the active water contained in the product, but not absorbed by the tissue product to be dried, removal of moisture may therefore at a low temperature (40-60 °C), which allows to keep practically vitamins bioactive substances, natural color, flavor and aroma of foods are dried.

Drying – one of the most widely used methods for preserving the basic food products, according to which the water content is reduced to a level at which the content and degradation microbes greatly minimized [1-2]. Drying also helps to reduce production losses and extends shelf life, thus making the seasonal produce available throughout the year. However, the physical, chemical and biochemical changes taking place during drying of the product, is one of the major problems which can result in a qualitative depreciation of the product [3], since the maximum temperature used for drying food products is not high enough to inactivate enzymes.. Application of heat, acting on fruit and vegetables for the purpose of drying , aims to stop the enzymatic activity and avoiding unwanted changes and sensory properties of food during drying and storage, increasing the quality of the product [4-5].

Water affects the physical nature and properties of the food complex manner due to interactions with their solutions, colloids and scattered particles [6]. Moisture in the product reflects the availability of water for destructive reactions and microbial growth, and this - one of the main variables in the control of food preservation technology [7-8].

Moisture from the interior of the wet material is moved to the interface due to mass conductivity. From the interface passed to the kernel moisture gas stream by convective diffusion.

Experience shows that when drying wet bodies in most cases, the drying rate varies significantly with changes in moisture content. There are three typical drying period. At the beginning of the drying rate is constant, independent of the moisture content. This (first) constant drying rate during the evaporation of moisture from the material is the same as with the free liquid surface. The process speed is limited by the convective diffusion of water vapor from the interface into the core gas flow.

The second drying period - the period of decreasing speed - characterized by the fact that the drying process is limited by mass conductivity inside the moist material, and convective diffusion fumes from the interface to the core gas flow has no significant effect on the drying process.

The drying rate in the third period is close to zero, at which point the material becomes equal to the humidity the equilibrium moisture content, which indicates completion of the drying process.

Until now, the drying of fruits and vegetables has been investigated for different products in order to determine the speed of drying, the influence of external factors such as temperature, radiation, acoustic waves, and during the drying of the product quality, machine performance. Results were obtained for a positive impact on low vacuum drying rate and quality of the dried product.

The purpose of this research – the study of the distribution of heat inside the dried product and the effect of temperature, vibration and vacuum in continuous and discrete modes of drying, to obtain analytical expressions of the experimental results [9-10].

METHOD AND MATHEMATICAL MODEL

It is known that in the second stage of drying when using a discrete mode, the drying time of exposure is small compared with the waiting time of the next exposure [11].

This physical condition at the surface absorption of infrared short - wave is fast enough. For this case is convenient to use the Dirac delta function.

We write the system of equations of heat conduction for the generalized Cauchy problem

$$\begin{cases} \dfrac{\partial u}{\partial t} = a^2 \Delta u + f(x,t) + u_0(x)\delta(t) \\ u_{t=0} = u_0(x) \end{cases}, \quad (1)$$

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where *Δ*-Laplace operator.

If the turn-on time is small compared with the time heat of distribution, the last term of the equation is sufficient to describe the effect of the heat pulse *δ(t)*-usually the Dirac delta function.

The system of equations (1) shows that the initial perturbation u_0 function, $u\left(\bar{x},t\right)$, where $\bar{x}=\vec{x}(x,y,z)$ which plays the role of instant active source which vanishes at *t≠0*. Generalized Cauchy problem for equation (1) with the source *F*, call the problem of finding a generalized function *u*, vanishing for *t≠0* and satisfies the heat equation

$$\frac{\partial u}{\partial t}=a^2\Delta u+F(x,t) \qquad (2)$$

Known theory that for generalized functions [12] is a solution in the form (3)

$$u=\int_0^t\int_V \frac{f(\xi,\tau)}{[2a\sqrt{\pi(t-\tau)}]^n}e^{-\frac{|x-\xi|^2}{4a^2(t-\tau)}}d\xi d\tau+\frac{\theta(t)}{(2a\sqrt{\pi t})^n}\int_V u_0(\xi)e^{-\frac{|x-\xi|^2}{4a^2t}}d\xi, \qquad (3)$$

where $F\left(\vec{x},t\right)=f\left(\vec{x},t\right)+u_0\left(\vec{x}\right)\cdot\delta(t)$

More A.N.Tikhonov [13] has shown that any band of *0≤t≤T* can use the estimate

$$|u(x,t)|\le C_T e^{a_T|x|^2}$$

Note that in the absence of internal heat sources *f=0,* and it remains to solve the problem with the last member of (3).

Since the initial momentum operates mainly on the surface layer, the authors of the initial stage of the temperature distribution for the nonstationary problem offer a solution by introducing a spatial delta function, that is when

$u_0\left(\vec{x}\right)=\delta\left(\vec{x}-\vec{x}_0\right)$ have

$$\int u_0(\xi)e^{-\frac{|x-\xi|^2}{4a^2t}}d\xi\to u_0\left(\vec{x}_0\right) \qquad (4)$$

When $\vec{x}_0\to 0$ we have to solve (3)

$$u=\frac{\theta(t)\cdot u_0}{2a(\pi t)^{\frac{3}{2}}}$$

In particular, a flat bed with the exact specification of temperature layers have

$$u=\frac{\theta(t)u_0}{2a(\pi t)^{\frac{1}{2}}} \qquad (5)$$

The resulting formula (5) shows that after a short exposure is a decrease of surface temperature changes under the law of the exponential function, and the irradiation temperature dependence of the temperature of the irradiated surface is hyperbolic.

RESULTS AND DISCUSSION

Fig.1 shows the concentration dependence of the depth of the layer of crystallized substances in the dried product.

The first graph, at *t=80 ^{0}C, P=-0.8 atm.,* is the most profitable tumble dryer if it aims – to save those or other substances on the surface layer. Indeed, in this mode, the weak diffusion transfer process competes with capillary transfer and crystallization processes, which involve skeletal growth due to crystal growth.

If we analyze the timing of the process where the temperature is kept at *t=60 ^{0}C*, and the pressure *P=0.8 atm.*, it is obvious decrease decay curve slope relative to the first mode.

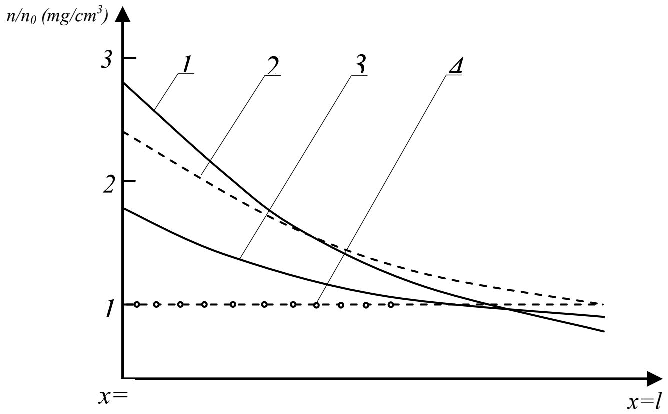


Fig.1. *Redistribution element inulin in Jerusalem artichoke isotropic weight due to various modes of drying: 1-t=80 ^{0}C, P=-0.8 atm.; 2-t=60 ^{0}C, P=-0.8 atm.; 3-t=80 ^{0}C, P=1 atm.; 4-t=25 ^{0}C, P=1 atm.*

The analysis result is explained by a reduction of the IR radiation, which keeps the temperature inside the chamber to a value not exceeding 60 ^{0}*C*. The second mode is advantageous for those used dewatered material which requires lowering the drying temperature. The third curve, as reflected in Fig.1. is obtaining a product curve at *t=80 ^{0}C, P=1 atm*. It can be seen that the drying process is carried out at atmospheric pressure, and the result is achieved relatively slowly, due to the lack of volume in boiling jerusalem artichoke layers.

Note that the gradient of inulin redistribution during drying at relatively low temperatures close to a constant value (Fig.1. curve 4). This experiment was made for the case where the metal pan, wherein the drying material is not heated. Boundary conditions also allow us to investigate the thermal conductivity correction job. But these processes are somewhat interrelated, and with non-linear mechanisms. In particular, when continuous redistribution of surface temperature due to radiation and evaporation is nonstationary. But, with a sufficient level of humidity or low irradiance comes some temporary balance, suggests a derivative of zero temperature. The unit receives a volume of material per unit of time the energy of irradiation, is equal to the amount of energy based on the liquid which undergoes a phase transformation. Such a condition is described by the equation

$$(ku_x)_x+\alpha I_0e^{-\alpha x}=0 \qquad (8)$$

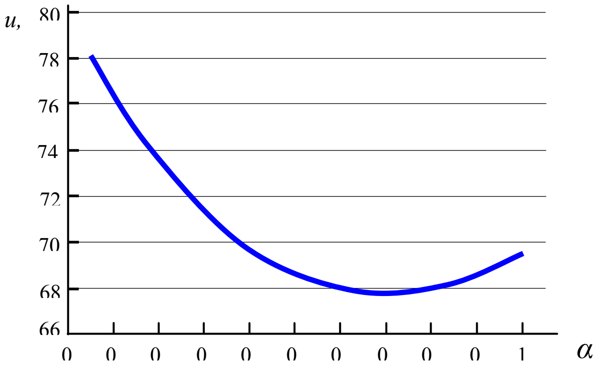
where, *k*-thermal conductivity; *u*-temperature; I_0-intensity incident infrared wavelengths; α-attenuation coefficient of infrared waves.

Equation (8) describes the stationary phase, the temperature field in a balance between energy intake and loss, excluding the volume of boiling. If you consider this factor we obtain,

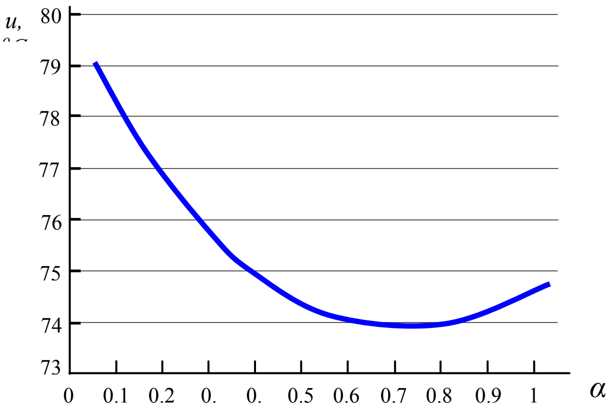
$$(ku_x)_x - \lambda m(1+\gamma\theta) + \alpha I_0 e^{-\alpha x} = 0$$

where λ-evaporation coefficient, m-number of liquid evaporation per unit volume, θ-function Hevsayda defined as $\theta=\theta(u-u^*)$, where u^*-boiling point of the liquid for a given unit of volume. Based on the fact that the product is proportional to the pressure difference λm, which in turn is proportional to the temperature, we have $\lambda^* m \sim \lambda^* u$.

This approach also allows you to assume that the coefficient $\lambda^*\gamma\sim n$, that is corresponds to the density of the object on the moisture evaporates. Consider drying mode when $u^*<u$. For a linear problem, where infrared rays irradiation reverses the secondary radiation of the materials received dates for redistribution of the stationary problem (Fig.2).



A



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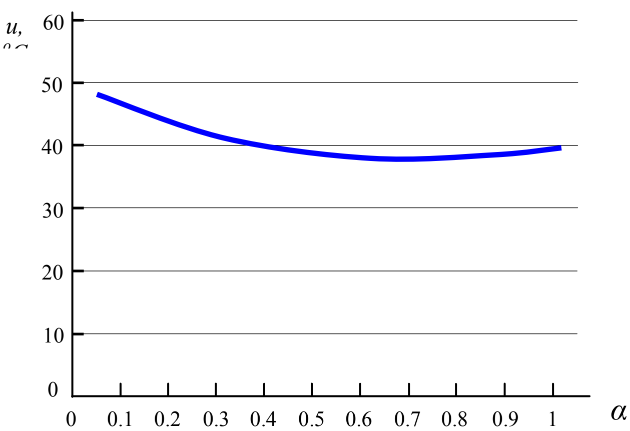

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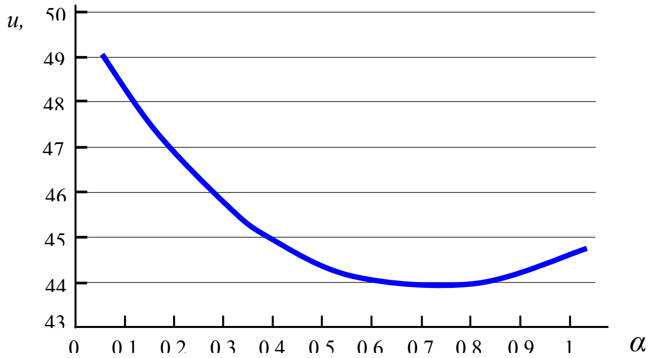

C

Fig. 2. *Dependence of the distribution of heat from the absorption depth u IR irradiation - αh for different temperature ranges: A–from 68 to 78 °C; B–74 to 79 °C; C–44 to 49 °C; D–38 to 48 °C*

The curves show the effect of the intensity of irradiation temperature on the redistribution layer thickness. This means that high levels of irradiation increases the temperature difference between the layers, wherein there is a minimum point. These results were obtained without evaporation volume so as $u<u^*$. Temperature rise at $\alpha h\to 1$ due to the fact that the authors have taken part of the distance that the heat flux is zero. This coefficient reflects 90%, which corresponds to the given boundary conditions.

CONCLUSION

The analytical results of applied research drying process using the methods of mathematical physics. The method of nonlinear waves and small parameter method for solving equations processes stimulated diffusion and thermal conductivity. The distribution of temperature for the stationary mode and for a short irradiation with infrared drying in discrete mode.

Experiments on redistribution layers crystallized substances during drying. In particular, the curves obtained for the distribution of jerusalem artichoke inulin having a specific layer. Experiments showed significant separation element inulin layers.

The results obtained by carrying out experiments allow to obtain new materials with high levels of drying the crystallized substances. And it means the availability of new products and innovative technologies for therapeutic foods.

REFERENCES

[1] Doymaz, I. The kinetics of forced convective air-drying of pumpkin slices. Journal of Food Engineering, 2007. v. 79, n.1, p. 243-248.

[2] Akpinar, E. K.; Bicer, Y. Modelling of the drying of eggplants in thin-layers International Journal of Food Science and Technology, 2005. v. 40, n.3, p. 273-281.

[3] Mujumdar, A. S. Drying Fundamentals. In BAKER, C. G. J. (Ed.). Industrial Drying of Foods. Baker: Blackie Academic & Professional, 1997. p. 7-30.

[4] Chantaro P., Devahastin S., Chiewchan N. Production of antioxidant high dietary fiber powder from carrot peels. Food Science and Technology, 2008. v. 41, n.10, p. 1987-1994.

[5] Wolfe K.L., Lui R.H. Apple peels as a value-added food ingredient. Journal of Agricultural and Food Chemistry, 2003. v. 51, n.6, p. 1676-1683,

[6] Park K.J., Yado M.K., Brod, F.P. Obtenção das isotermas de sorção e modelagem matemática para a pêra bartlett (Pyrus sp.) com e sem desidratação osmótica, Ciência e Tecnologia de Alimentos, 2001. v. 21, n.1, p. 73-77.

[7] Van Den Berg C., Bruin S. Water activity and its estimation in food systems: theoretical aspects. In: ROCKLAND L.B., STEWART G.F. (Eds.). Water activity: influences on food quality. New York: Academic Press, 1981.

[8] Lucídio M.F., Ana Karla R.G., Maria A.M., Elen C.F. Moisture sorption isotherms of fresh and blanched pumpkin (Cucurbita moschata). Food Science and Technology (Campinas). 2011. vol.31 n.3 Campinas July/Sept .

[9] Norkulova K.T., Safarov J.E., Fakhrutdinov R.R. Speed up the drying process. Bulletin of Tashkent state technical university, 2012. №1-2. p.98-101.

[10] Norkulova K.T., Umarov V.F., Mamatkulov M. Functional foods and methods of agricultural drying. International Journal of Agricultural. 5.2008. p.48-49.

[11] Norkulova K.T., Fakhrutdinov R.R., Safarov J.E., Mamatkulov M.M. Ensuring uniform infrared radiation for drying a flat layer. //Chemical Technology. Control and management. -Tashkent. 2012,№1. p.16-19

[12] Vladimirov V.S. Equations of mathematical physics. - M.: Publishing House of Science FIZMATLIT, 1981. -512 p.

[13] Sveshnikov A.G., Tikhonov A.N. The theory of functions of a complex variable. -M:. FIZMATLIT, 2005. -336 p.