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Kinematic Aspects For Justifying The Parameters Of The Chamber-Type Tray Dryer.

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ABSTRACT

On the basis of the adopted scheme for obtaining molded-granulated products, a dependence characterizing the kinetics of drying the protein-carbohydrate and protein-vitamin granules was obtained. Using the obtained dependence, the calculation formula for the determination of the capacity of a tray drier of a chamber type is justified.

Keywords: molding, granules, method, scheme, kinetics, dependence, drying time, drying capacity.

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INTRODUCTION

It is known that the production of molded dried products is the most effective way of storing and using them. In this case, products are obtained in various forms and compositions, which is due to the practice of their application [1].

At present, the main methods for producing molded products are so-called dry and wet pressing. In some cases, due to the conditions of production of products, depending on the composition and properties of the raw materials and components, the most effective is the production of granules with a screw press and their subsequent drying in chamber type dryers. According to a similar scheme, there are lines for the production of pasta, cottage cheese, etc. [2, 5-11].

MATERIALS AND METHODS

The aim of the research is the theoretical justification of the parameters of the process of the trough dryer by disclosing the kinetics of drying and obtaining a calculation formula for determining its productivity.

Research objectives:

- in accordance with the adopted scheme for obtaining a wet granulate and a method for its dehydration by drying to justify its kinetics;
- on the basis of the established kinetic dependence, obtain a design formula for determining the capacity of a tray type chamber-type dryer.

RESULTS AND DISCUSSION

The analysis of the existing schemes for obtaining protein-carbohydrate and protein-vitamin granules showed that the most complete conditions for their production from soybean and other plant raw materials are the scheme that includes the following sequence of operations:

- soaking seeds of soybean-cereal composition (SCC) → disintegration of SCC in aqueous medium with simultaneous extraction of nutrients from SCC → separation of insoluble (pulp) soybean-grain residue from liquid fraction → granulation and drying.

At the same time, a thermal acid coagulation of protein substances with a solution of ascorbic or succinic acid or their composition is carried out in the liquid fraction to produce a protein-vitamin coagulate in the form of a curd mass.

Based on the resulting mass, pellets are formed and are dried [3].

According to the technological scheme for obtaining protein granules, the final stage of their preparation is the drying process to a moisture content of 8-11%.

To substantiate the parameters of this process, an approach is adopted, the essence of which is that the drying process is carried out by removing water molecules from the granules of the protein product, under the influence of a temperature gradient, that is, leaving it, reducing the mass and moisture of the granulate. In this case, there is a need to establish the relationship:

$$W_x = f(C_n ; C_k),$$

where C_n , C_k - initial and final number of water molecules in the structural grid of the granulate.

On this basis, the general form of the functional relationship between the process parameters and the current moisture content in the granulate can be represented as

$$W_i = f(t^0\,; \tau_c;\, d_g) \rightarrow min\ , \quad (1)$$

where t^0 - temperature of dehydration of the granulate during the drying process;

τ_c - drying time;

d_g - diameter of the granulate, which characterizes its size and shape.

In this case, as a differential equation of the change in the concentration of moisture in the granules during the thermal action on them, one can present a dependence of the following type

$$\frac{dW}{d\tau_c} = k \cdot W, \quad (2)$$

where W - moisture content of the granulate, characterized by the concentration of water molecules in it;

k - coefficient characterizing the intensity of moisture removal from the structural grid of granules.

It is quite obvious that the values of this coefficient depend and are determined by the time of dehydration - τ_c, energy, leading to the activity of the movement of water molecules – E, as constant, absolute temperature -T, and also, the so-called coefficient characterizing the connection of water molecules with the material of the granule (the composition of the product and its properties) -K.

In view of the foregoing, we have that

$$k = e^{K-E/RT}. \quad (3)$$

Integration of this dependence in the drying time interval from $\tau = 0$ to $\tau = \tau_c$ gives the following equality

$$ln\frac{W_H}{W_K} = k \cdot \tau_c \quad (4)$$

Expressing the meaning τ_c from equation (4) with allowance for (3) we obtain that

$$\tau_c = \frac{ln^{W_H}/_{W_K}}{exp(K-E/RT)} \quad (5)$$

The driving force for changing the concentration of moisture in the granules is the difference between the values W_H and W_K, those

$$\Delta W = W_H - W_K \quad (6)$$

The average value of this parameter is defined as the average logarithmic and, then we have that,

$$\Delta W_{cp} = \frac{2{,}3\cdot(\Delta W_{max} - \Delta W_{min})}{lg\left(\Delta W_{max}/_{\Delta W_{min}}\right)} \quad (7)$$

Then, the amount of moisture removed from the granules during their dehydration by temperature drying in accordance with the theory of mass transfer [4] will be

$$M_c = \frac{2{,}3 \cdot \varepsilon \cdot F \cdot (\Delta W_{max} - \Delta W_{min}) \cdot ln\left({W_H}/{W_K}\right)}{lg\left({\Delta W_{max}}/{\Delta W_{min}}\right) exp\,(K - E/RT)}, \qquad (8)$$

where ε - mass transfer coefficient;

F - surface area of mass transfer.

The value of the mass transfer coefficient depends on the resistance to the mass transfer process in the boundary layers, characterized by the transport coefficients β_1 and β_2.

According to [1], we have

$$\frac{1}{\varepsilon} = \frac{1}{\beta_1} + \frac{1}{\beta_2}$$

from which we obtain

$$\varepsilon = \left(\frac{1}{\beta_1} + \frac{1}{\beta_2}\right)^{-1}$$

Finally, equality (8) takes the following form

$$M_c = \frac{2{,}3 \cdot \left(\frac{1}{\beta_1} + \frac{1}{\beta_2}\right)^{-1} \cdot F \cdot (\Delta W_{max} - \Delta W_{min}) \cdot ln\left({W_H}/{W_K}\right)}{lg\left({\Delta W_{max}}/{\Delta W_{min}}\right) exp(K - E/RT)}. \qquad (9)$$

Taking into account the dependence (5), a formula is obtained for determining the productivity of a chamber type drier with an actively moving coolant

$$Q_c = \frac{M_g \cdot [exp(K - E/RT)] \cdot (100 - W_H)}{100 \cdot ln\left({W_H}/{W_K}\right)} \qquad (10)$$

CONCLUSION

On the basis of the approach, a dependence was obtained that characterizes the kinetics of the degreasing process of protein-carbohydrate (PCG) and protein-vitamin granules (PVG) by drying them in a chamber-type tray drier. Taking into account this parameter, in the general sense, characterizing the drying kinetics of the granulate, which has its specific composition and properties, a formula is obtained for calculating the capacity of the dryer, depending on the specific conditions for its use (in the production line of PCG and PVG).

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