LIQUID MATERIALS DRYING IN THE DRYER OF PSEODOLIQUIFIED LAYER WITH AN INERT CARRIER

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Abstract: In this paper is justified the choice of pseodoliquified layer apparatus for drying liquid foods, the results of experimental studies of the kinetics of convective drying of milk protein concentrate are presented.
Keywords: drying, milk protein concentrate, kinetics, pseudo liquefaction.

Nutritional value of milk and milk products is determined by the content of biologically valuable and easily digestible proteins. The total deficit of dairy resources that exist today, the high volume of raw materials with low functional properties leads to losses of proteins, minerals and vitamins. Traditional technology of industrial processing of milk in foods such as butter, cheese or cottage cheese, are inevitably associated with obtaining of such sub products as skim milk, buttermilk and whey. These products are valuable raw lactic protein [1,2].

The main task in the dairy industry is a more rational use food potential of milk with the introduction of clean technologies of processing. One of such directions is the production of dairy protein concentrates (DPC), which are obtained from skimmed milk or whey by removing water, minerals and lactose with simultaneous concentration of milk proteins. Dry DPC have moisture content to 12%.

Development of technologies for DPC is of considerable interest in the task of competitive food products creating, elimination of protein deficit, increasing the biological value of mass consumption products.

DPC, like all dairy products, refers to perishable. Therefore, to obtain a product more stable during storage, less prone to bacterial spoilage and convenient for transportation it assumes to use drying.

Drying of pasty and liquid materials obtained by production of many food products: milk, buttermilk, whey, juice - is a very complex task.

For liquid materials drying, need to create certain hydrodynamic conditions: spraying, distribution of a thin layer, mixing in volume. The above conditions are realized in the spray, roller, rotary, vacuum and screw dryers. Furthermore, there may be a combination of spraying and applying thin layers of liquid material on the surface of inert bodies or granules in drum dryers, granulators or pseudo liquefied layer dryers. Drying in the foam layer is carried out in foam dryers, which are used in the meat and dairy industry. Necessity of large amounts of moisture evaporation causes a significant increase in the consumption of thermal energy and thermal agent, which is associated with an increase in size of dryers, and with cost rising of cleaning systems for drying agent waste. In addition, the drying of liquid materials is accompanied by formation of the morphological structure of the product particles, and in the case of spray drying – dust formation.

These features cause the direction of development and improvement of technology and equipment for drying liquid materials: maximum energy savings, intensification, solving the problem of air cleaning from dust, formation at the drying step necessary particle size and particles structure of the finished product. In many cases it is possible a complex solution to these issues.

Atmospheric or vacuum roller dryers have high efficiency but they have low productivity and are limited in use, due to the properties of drying objects. The same can be said for the rotor and screw dryers.

The most universal are spray dryers, which are suitable for almost any liquid drying objects. Drying is achieved in them by dispersing liquid material provided by nozzles, centrifugally and disc or acoustic devices in the space of the drying chamber in which is fed simultaneously hot drying agent. For a uniform drying of product is necessary good mixing of gases and droplets of dispersed material therefore these devices operate in a mode close to ideal mixing. To prevent ingress of sprayed material on the drying chamber walls, the dryer must have a sufficiently large volume, resulting in a low concentration of material particles in the drying area. Therefore the main way of intensification of spray dryers is to increase degree of dispersion of the dried material. Besides, a fine and uniform spraying allows drying the material at a much lower final temperature of the drying agent, which gives increase of energy efficiency of drying process or reduction the drying agent consumption.

For thermo stable solutions intensification of the spray drying process is achieved at preliminary solutions overheating. By this method the solution at pressures up to 1.5 MPa is superheated to a temperature that is a few degrees below of its boiling point at a given pressure to avoid formation of a two phase system in the heat transfer tubes. Superheated solution when exiting from the spray nozzles occurs ebullition of dispersed droplets with moisture evaporation due to accumulated heat.

The ability of liquids to stick on the surface of solids is not used only for dust separation or product agglomeration, but also for getting it in granulated form. On a combination of spraying and applying of thin layers liquid are based many devices that combine the processes of drying and granulation. An additional possibility for drying process intensification provides a spraying method of a liquid material in suspension layer of product or inert bodies. This process is organized in apparatus of boiling or gushing layer. In such devices, the concentration of dried material and respectively working area volume tension by moisture evaporation for several times is higher than concentration of material and moisture evaporation in conventional convective dryers. When are drying pastes, solutions and suspensions, as a layer of granular material are used granules or inert material (sand, porcelain balls, fluoroplastic chips, etc.).

The first method is used when the material is heat-resistant enough in dry condition, forms relatively strong granules, and the dried product (according technical requirements) is desirable to obtain in the form of granules. This product does not become caked during storage, not dusty when is applied.

In the second method, a viscous paste distributed between forming a layer inert particles, which are covered with a thin film of wet material when solutions and suspensions are feed. As the drying film is wiped or chipped during collisions of particles and material is hand down in the form of dust or scales and is carried from the dryer by thermal agent. This method can be used for drying thermally unstable substances, when the material in the drying process goes from elastic-plastic to elastic-fragile state, if necessary to obtain a dried product in a finely dispersed form and in the case when are formed very fragile granules.

First time drying in boiling layer for the evaporation of solutions and suspensions was proposed in 1953. Then method was used for the evaporation of sea water and dehydration of solutions and melts. In food technology, this method began to be applied much later. This method can also dry the products with low melting point or products requiring conservation of vitamins and other useful substances (up to 60 °C). Complexity of the processes in the pseudo liquefied layer is associated with its features as the dispersed system in which appears chaotic local pulsation (pseudo-turbulence) of both phases. The emergence of chaotic pulsations is due by interaction of carrying flow of a continuous medium with random concentration fluctuations of the dispersed phase. By virtue of this the particles trajectory in the pseudo liquefied layer is random. It should be noted that the process of solutions dehydration in a pseudo liquefied layer refers to the category of processes that depend on the trajectory of the particles. Indeed, according to our preliminary studies, the granule if it enters the flame zone of a spray nozzle is irrigated by product, and then moves away in the main volume of the layer, where is carried out drying of wet film. DPC solution has high adhesion to the surface of inert bodies therefore, as inert bodies' material we have used fluoroplastic cubes adhesion to the surface of which was minimal.

In the first stage of researches we determined the influence of semi-finished product layer thickness on drying kinetics. In the real process is practically impossible to follow the kinetics of the film product drying process, which is located on a single granule of inert in pseudo liquefied layer. Therefore the preliminary experimental studies of DPC solution drying kinetics we spent in circulation convection dryer on fluoroplastic substrate.

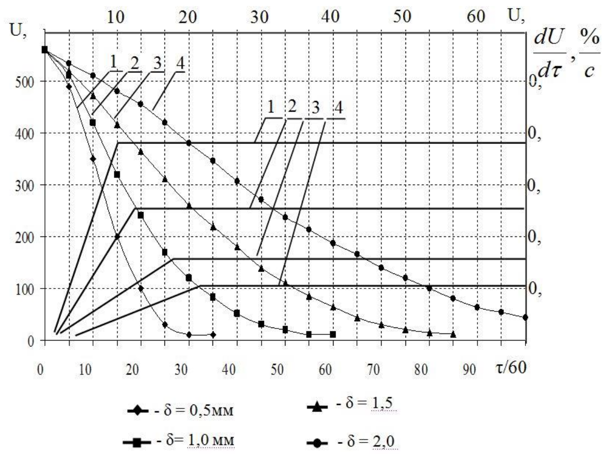

Fig. 1. Drying curves (1, 2, 3, 4) and drying speed (1 ', 2', 3 ', 4') of DPC buttermilk solution film on fluoroplastic substrate, depending on the layer thickness at thermal agent temperature of 70 °C

This study of the process was performed for a layer with different thickness (from 0,5 to 2,0 mm), $1{,}17\cdot10^{-2}$ m2 area at thermal agent temperature of 60-70 °C. In the study of the semi-finished product drying process on the substrate product was applied by pouring on the plate-substrate, we measured the sample weight, the application area and film thickness of the solution.

Results of experimental studies allowing estimating kinetics of the drying process are shown in Figure 1.

It is established that the drying process occurs in two periods - permanent and with falling drying speed, areas of which are clearly distinguished on the curves of drying. The critical moisture content Ucr, representing boundary between first and second periods, increases with increasing layer thickness. Thus, for DPC film solution with 0,5 mm thick, it is 100%, for a film thickness of 1.0 mm - 120%, 1,5 mm - 180%, 2,0 mm - 210%.

From the presented in Figure 1 graphic dependences it follows that an increase in layer thickness two times (from 0.5 mm to 1.0 mm), the drying time up to a certain moisture content is also doubled. Similar dependence is observed at other relations of thickness (up to 2.0 mm) and the drying process duration. However at DPC drying solution with thickness greater than 2,0 mm for $7{,}2 \cdot 10^3$ *s* its moisture content was 37% due to formation of a dense film on the solution surface, that prevented the removal of moisture from the inner layers. Therefore, further studies of DPC drying process with film thickness more than 2,0 mm is not considered appropriate. Analysis of performed experimental studies determined that in terms of minimizing energy costs, DPC rational layer thickness should be 0,5-0,8 mm.

Thus the performed study of DPC convective drying kinetics allowed to establish rational modes of DPC solution drying in pseudo liquefied layer with inert carrier (t = 60-70 °C, δ = 0,5-0,8 mm), determine carrier material (4 fluoroplast cubes with edge 4 mm) and to obtain a number of indicators for theoretical justification of process. To establish the relationship between kinetics of drying and kinetics of DPC film thickness growth on carrier granules are done studies.

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