ANALYSIS OF FOOD DRYING PLANTS

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The selection of the appropriate type of drying for a food product is determined by the required quality of the final product, the nature of the dried food product and the production costs of the process. Several types of drying are used commercially and some types of drying are suitable for other foods [1].

Rotary dryer. This dryer is shown in fig. 1.2 and has the shape of a cylinder moving around its axis. The cylinder is connected to the rotating tool and is positioned at a slight angle. The inner surface of the cylinder is equipped with a drive that mixes the material. Hot air moves in one and the other direction as dry material enters the dryer [1-4].

Fig. 1.2. Rotary dryer

Conveyor dryer. The layer of material to be dried is slowly transported on a conveyor through a drying chamber or tunnel equipped with an air heater and a fan, as shown in fig. 1.3 [1-10].

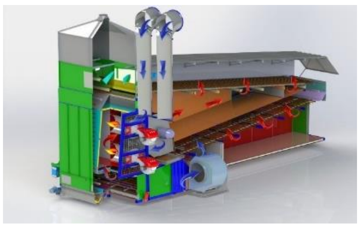

Fig. 1.3. Conveyor dryer

Vacuum drying is used to improve the quality of the finished product, since the drying process occurs at a lower temperature than under atmospheric conditions [1, 11, 12].

During vacuum drying, the rate of moisture evaporation increases, since it is directly proportional to the difference in water vapor pressure at the surface of the material and in the surrounding space. The efficiency of the process also increases - due to the absence of heat loss with the exhaust air. Heat for evaporating moisture during vacuum drying is most often transferred by contact, less often by infrared rays. The mechanism of heat and moisture transfer is similar to that during contact drying [1].

Vacuum drying requires the presence of a vacuum at which the boiling point of water is above 0 °C. When water evaporates, it passes from a liquid to a gaseous state, and products during such drying are deformed in the same way as during atmospheric drying. The method is used when drying paste-like root vegetables or crushed products [1, 13, 14].

1-chamber; 2-hollow slabs.

Fig. 1.4. Vacuum drying chamber

Vacuum drying cabinets (Fig. 1.4) are the simplest contact dryers of periodic action. This dryer is a cylindrical chamber containing hollow plates heated by steam or hot water. A layer of material up to 60 mm thick is placed on baking sheets mounted on plates; the tension of their working surface usually does not exceed 0.5-3.5 kg/(m^2 h) of moisture. During operation, the chamber is hermetically sealed and connected to a vacuum condensation system and a vacuum pump [1, 13, 14].

Tray dryers. Tray dryers are used for batch drying of solid food products on a small to medium scale. They are inexpensive and easy to make. Tray dryers consist of a closed compartment in which trays with food products to be dried are placed (Fig. 1.5) [1, 15-17].

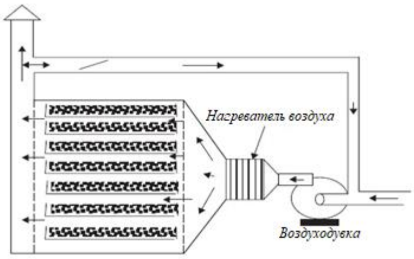

Fig. 1.5. Tray dryer

The trays will be installed on shelves with sufficient distance between them (Fig. 1.5). Heated dry air circulates between the shelves. Very often the bottom of the trays has a grid or perforation to allow some air flow through the trays as well. The drying speed, and therefore the moisture content of the material, depends on its position on the tray. The material closest to the dry air inlet has the lowest moisture content. To ensure more even drying, you can change the air flow direction or rotate the trays periodically [1]. The cabinet is usually equipped with movable partitions that are adjusted to ensure even distribution of the drying air throughout the cabinet. Tray dryers are often found in rural areas, where they are used for drying fruits (grapes, dates, apples), vegetables (onions, cabbage) and herbs (parsley, basil, mint, dill). The inlet air temperature is usually in the range of 60-80°C. The air speed is several m/s and must be adjusted depending on the size, shape and density of food particles in order to avoid the carryover of dry particles by the wind [1]. Depending on the product and conditions, the batch duration is usually from 2 to 10 hours. Most tray dryers have provisions for controlled air recirculation. The recirculation rate increases as drying progresses, when the air leaving the box has a higher temperature and lower humidity. Recycling results in significant reductions in energy costs [1,18-21].

Tunnel dryers. Tunnel dryers consist of long tunnels through which carts carrying stacks of trays move with or against the flow of drying air (Fig. 1.6). The dried material is evenly distributed among the trays. The typical load on a tray for wet vegetables is about 10-30 kg per m2. As one truck with wet material enters the tunnel at one end, another truck with dehydrated product exits at the other end. Depending on the size of the trucks and the tunnel, the trucks are moved manually or mechanically, such as with chains. With regard to the relative direction of air movement and the cart, tunnel dryers operate in direct flow, countercurrent or mixed flow (Fig. 1.6) [1, 12-14].

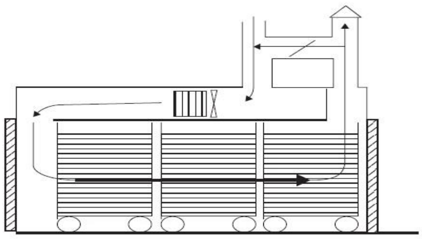

Fig. 1.6. Tunnel dryer

This provides the greatest "driving force" for drying and therefore the fastest rate of water transfer at the tunnel entrance. If the source material is sufficiently wet, its temperature remains low despite contact with hot air. However, the "driving force" decreases as the product moves toward the exit.

Consequently, the final residual moisture content of the product may not be as low as desired. In the case of counterflow tunnels, the opposite occurs. The initial drying rate is lower, but it is possible to dehydrate the product to a lower final moisture content. The central mixed-flow exhaust tunnel functions as two tunnels connected in series [1]. Its first part is direct-flow and provides the required high initial drying speed. Its last part is countercurrent and gives the necessary finishing effect. The temperature and humidity of the air can change the speed of its movement. In one model, used for drying fruit, the tunnel is designed as two consecutive blocks with the smallest cross-section (Fig. 1.7) [16-18].

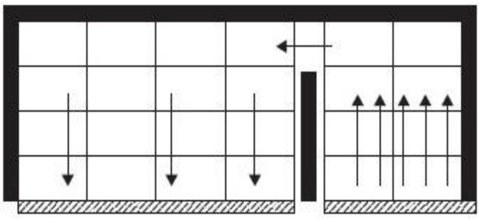

Fig. 1.7. Flow patterns in tunnel dryers

Drum dryers. The basic principle of operation of the heated surface is the shell of a rotating horizontal metal cylinder. The cylinder is heated by steam condensing inside at a pressure ranging from 200 to 500 kPa, bringing the temperature of the cylinder wall to 120-155 °C. The wet material is applied to the surface of the drum in a relatively thin layer in a variety of ways, which will be described below. The dried product is removed from the drum using a blade (Fig. 1.8) [17].

Drum dryers differ in the method of applying wet material to the surface of the drum: single-drum and double-drum. Double drum dryers consist of two drums rotating in opposite directions, with a narrow, adjustable gap between them. The so-called "double drum" dryer actually consists of two independent single drums rotating in the same direction, with common auxiliary devices [1].

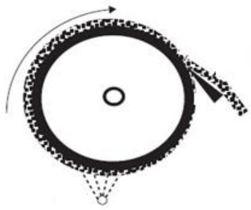

Fig. 1.8. Drum dryer

With high-frequency drying, heat is created using a high (10-25 MHz) and ultra-high (2000-2500 MHz) frequency electric current field [3,4].

In an electric field of high and ultra-high frequency, heating of product particles occurs in a fraction of a second. Under the influence of an alternating high-frequency electric field, controlled heating of the material occurs. Due to the evaporation of moisture and the effects of heat and mass exchange with the environment, the surface layers dehydrate and lose heat. Therefore, the temperature and humidity inside the product are higher than outside. Gradients of temperature and moisture content arise, due to which moisture from inside the product moves to the surface. In this case, unlike convective drying, the direction of both ingredients coincides, which intensifies the drying process [3].

Research by KrasGAU scientists led by corresponding member of the Russian Academy of Agricultural Sciences N.V. Tsuglenkom show that the greatest efficiency of using HF and microwave fields in agriculture is achieved in technologies for preparing seeds of agricultural and medicinal crops for sowing [4-6].

Research carried out at ChIMESKh (now ChSAA) in the second half of the twentieth century, under the guidance of prof. S.P. Lebedev, confirm the effectiveness of the impact of EMHF on vegetable seeds during pre-sowing treatment [1,7].

At Moscow State Agrarian University named after. V.P. Goryachkina under the leadership of academician. The Russian Academy of Agricultural Sciences I.F. Borodin conducted research on a wide range of issues related to the use of electromagnetic field energy in various technological processes, including heat treatment of agricultural raw materials [8,9].

Advantages of the method: the ability to regulate and maintain the temperature inside the product [4].

Disadvantages of the method: high energy costs, complex equipment and maintenance. This drying method is 3-4 times more expensive than convective drying [4].

High frequency currents are currently used to intensify freeze drying.

Since the late 1980s, the use of infrared heating in the drying of agricultural raw materials has sharply increased. Currently, infrared radiation is widely used in various industries [13-16].

During radiation drying, heat that heats the material and evaporates its moisture is transferred by the energy of infrared rays, the sources of which are special lamps, ceramic burners or other ceramic surfaces [17]. The depth of penetration of IR rays into the dehydrated product is practically from 5 to 15 mm.

As the wavelength of IR rays decreases, the penetration depth increases. The wavelength of maximum radiation is determined by the formula:

$$\lambda_{max} = \frac{2886}{T}, \text{ mkm.} \qquad (1.1)$$

The duration of drying with IR rays is significantly less time than that spent in research by other methods. This is achieved due to a high temperature gradient (2-5 degrees/mm inside the heated body). The quality of the products obtained by radiation drying is high [1].

Disadvantages include contact of the product with oxygen contained in the air; overheating of the surface due to the temperature gradient; possible formation of a hard crust on the surface; increase in cost due to electricity use [15-17].

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