Experimental study of a drying installation for drying melon with IR-radiation

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Abstract. The article presents the results of experimental studies of a newly developed drying installation for drying melon using the convective method in continuous motion with simultaneous exposure to infrared radiation. Experimental studies have established that when passing a chain conveyor in the collector area, melon slices are exposed to infrared rays, which speeds up the drying process. IR rays have a good effect in the initial period of drying, and in the second period, exposure to rays is not necessary. A drying unit with infrared radiation provides high technical and economic indicators for drying ring-shaped melon slices, therefore it is recommended for its use in small and medium-sized farms specializing in the production of dried melon.

1 Introduction

Melon production in the agricultural sector of Uzbekistan occupies one of the leading places. Currently, the area under melon cultivation is 63 thousand hectares, and the yield in 2022 exceeded 850 thousand tons. With the correct agricultural technology for cultivating melon on moderately saline soils (Syr Darya, Khorezm and Kashkadarya regions), its yield is 350-400 c/ha [1].

High-sugar melon fruits are good raw materials for industrial processing to produce a wide range of food and technical products: melon jam, concentrated melon juice - bekmes, dried melon, candied fruit, vegetable oil and protein flour from the peel.

It has been established that with waste-free processing from 1000 kg of melon fruits you can get: 155–165 kg of melon jam or 65–70 kg of bekmes or 70–75 kg of dried melon; 2.5–3.0 kg of vegetable oil; 20-23 kg of protein flour [2-5].

Currently, the only predominant product from the processing of melon fruits is the production of dried (dried) melon. Such production is concentrated mainly only in Uzbekistan and Turkmenistan, characterized by a hot climate and long sunny days and a rich variety of high-yielding varieties of melons.

Drying melons is carried out mainly by small farms and private farmsteads, using mainly manual labor. The technology is based on the air-solar drying method, by hanging peeled melon slices on hangers or horizontal poles, which did not meet sanitary and hygienic standards and depended on weather conditions. Dust settled on the dried melon, as a result of which the quality of the final product did not meet technical specifications.

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In this regard, the development of intensive methods for drying melon and drying plants for industrial use is urgent and in demand.

2 Problem statement

On the basis of patent and licensing searches and literary sources, to develop a highly efficient drying installation suitable for drying melon slices, ensuring uniformity and high quality of dried products, as well as simplicity and convenience in its operation.

The objectives of the study include as follows:

- creation of a drying installation design taking into account physical biological and technological properties of melon;
- conducting scientific and experimental research on drying melon;
- research of the operating and technological parameters of the drying process;
- research of the influence of IR radiation on the drying process;
- determination of the influence of air flow speed on drying speed.

3 Materials and methods

The research was based on the well-known method of drying melons [6] including peeling and peeling, removing the testes, cutting the melon into rings perpendicular to its axis 15–20 mm wide, followed by stringing the rings on horizontal rods and drying in a stream warm air.

The goal of the research is to create a design of a drying installation that would ensure ease of operation and drying of melon by convective method in continuous motion with simultaneous exposure to infrared radiation.

The essence of the drying installation is illustrated in Figure 1 which shows a general view; and in Figure 2 which demonstrates a chain conveyor link with folding clamps. Figure 3 shows a collector with infrared emitters [7-8].

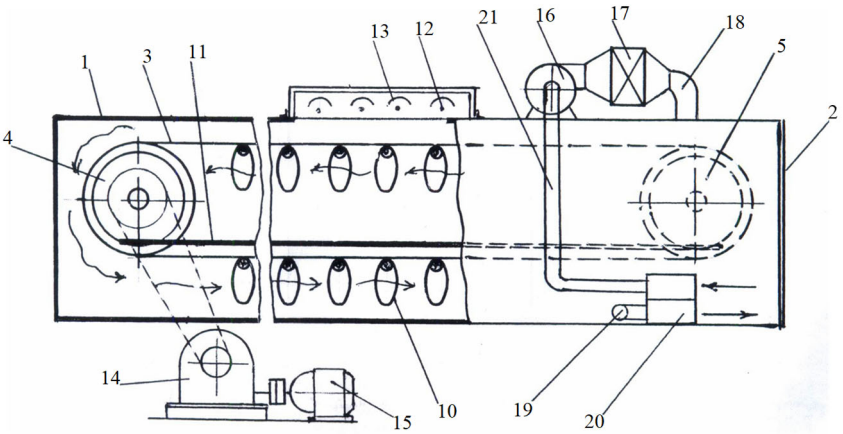

Fig. 1. General view of a chamber-chain drying plant for melon drying.

A chamber-chain drying installation for drying melon contains a drying chamber 1 with a door 2, inside which a chain conveyor 3 with 4 driving and 5 driven sprockets is installed. Folding clamps 7 with clamps 8 are attached to the conveyor links 6 with a certain pitch, onto which poles 9 with melon slices 10 are placed. The chamber body is divided by a longitudinal partition 11 located between the branches of the chain conveyor. A collector with IR emitters

12 with reflectors 13 is installed on the chamber. The chain conveyor is equipped with a worm gearbox 14 and an electric motor 15.

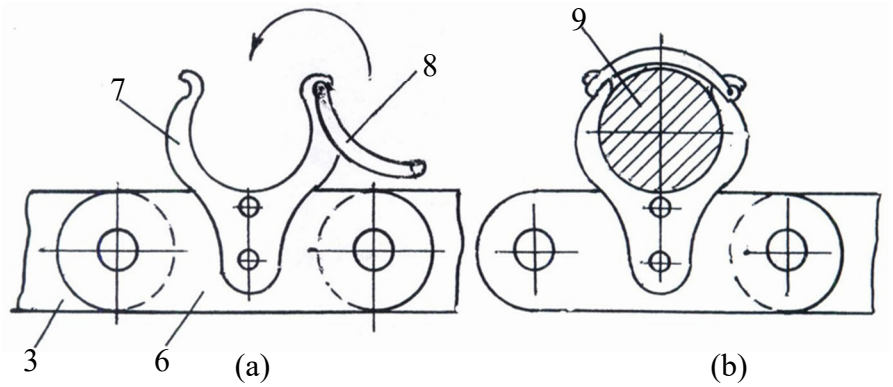

Fig. 2. Chain conveyor link with folding clamps.

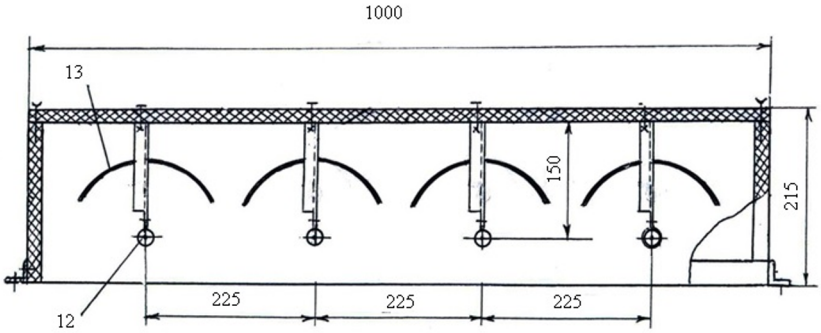

Fig. 3. Collector with infrared emitters.

A fan 16, an electric heater 17 and an inlet socket 18 for the drying agent are installed on top of the drying chamber. The outlet pipe 19 is located in the lower part of the chamber and communicates with the exhaust chamber of the annular regenerator 20, the discharge chamber of which communicates through the air duct 21 with the suction pipe of the fan.

The operating principle of the installation is as follows. After peeling, the melon is cut into ring slices perpendicular to its axis, the width of the resulting ring is 15–20 mm (following the example of A.S. No. 1722374). Then the melon rings are strung on poles with an interval of 20–25 mm between them. With the door open and the discrete-cyclic movement of the chain conveyor, the prepared poles are placed on the conveyor and secured on both sides with folding clamps, which are made of elastically deformable spring steel and in the free position the horns have a lyre-shaped shape. After laying the pole, it is secured by turning the clamp.

Having thus completely loaded the chain conveyor, close the door, start the fan and electric heater and turn on the conveyor drive to constant operation. To intensify the drying process, IR radiation sources are turned on.

Being in a constant movement mode, the melon slices are subjected to convective drying due to the hot air entering through the bell, heated in the air heater. In this case, infrared rays, reflected from the surface of the reflectors, affect the melon slices hanging on the poles. It is known that IR rays, when exposed, destroy the quasi-stationary structure of plant materials and promote the evaporation of moisture.

The spent drying agent, together with evaporated moisture, goes around a longitudinal partition, conditionally dividing the air space into upper and lower zones, and through the latter enters the outlet pipe of the annular regenerator. The low-grade heat of the exhaust temperature drying agent $t = 50 - 60^0C$ is used to heat the freshly incoming outside air.

4 Methods

According to the description, a prototype of the drying unit was manufactured. The camera body was made of rolled steel sheet with a thickness of $\delta = 1{,}4mm$. Overall dimensions: length – 4750 mm, width – 700 mm, height – 2110 mm. An electric heater PGS-018T was used as an air heater, power consumption was 8 kW (Manufacturer: Tashelektroapparat OJSC). Fan VTs-4-70 No. 5 with an adjustable throttle valve [8]. IR emitters brand KGT 220–500, spectral range 0.8…2.0 μm. A total of 4 pieces were installed. emitters complete with reflectors. The chain conveyor was made on the basis of a single-row roller chain PR-38.1-12700 (GOST 13568-75).

5 Results and discussion

To test the drying installation in real conditions, melon pulp of different varieties was used with different sample thicknesses: 15, 18, 21 mm. The one-time loading into the dryer was about 120–125 kg of pulp. Drying modes: air temperature at the initial period $t = 75 - 82^0C$, and at the end $t = 55 - 60^0C$. The heat flux density varied within the range $q_{\text{нв}} = 0.8 - 2.0\ kW/m^2$. The air flow was regulated by a throttle valve, and its speed was kept within the range of $2{,}5m/s \leq \vartheta_{\text{в}} \leq 4.5m/s$. The speed of the chain conveyor was constant $\vartheta_c = 0.0125m/s$. Pulsed treatment with IR rays $\tau = 50 - 120s$ at a wavelength $\lambda = 0{,}8 - 2{,}0$ μm, switching on the electrical circuit is fan-shaped in a checkerboard pattern.

Analysis of experimental data showed that in the initial period of drying, at a wavelength of IR rays close to $\lambda = 1.4 - 2.0$ μm, intense absorption of radiation energy by water molecules is ensured, due to which the process of removing moisture from melon slices is accelerated. The total drying time was $\tau = 18\ hours$ at final humidity $W_k = 19\%$, while the (calculated) specific energy consumption for drying melon from 85% humidity to 19% amounted to 20,500 kJ per kilogram of dried product. A total of 23 kg of dried melon of straw-yellow color with a sickly sweet melon taste was obtained [9-10].

In addition, it was noted that in the second drying period, infrared radiation is not necessary, since with a decrease in moisture, the permeability of infrared rays also decreases. Depending on the density of the melon pulp and the frequency of stringing the melon slices onto the pole, you can change the load on infrared radiation. Currently, the operating and technological parameters of the drying process and its optimization are being worked out.

6 Conclusion

Thus, it can be stated that the developed new design of a chamber-chain drying plant with infrared radiation has provided high technical and economic indicators for drying ring-shaped melon slices, as well as its feasibility of use in small and medium-sized farms specializing in the production of dried melon.

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