INTENSIFICATION OF APPLE DRYING USING CONVECTIVE AND COMBINED METHODS OF DEHYDRATION
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ІНТЕНСИФІКАЦІЯ СУШІННЯ ЯБЛУК ПРИ КОНВЕКТИВНОМУ ТА КОМБІНОВАНОМУ СПОСОБАХ ЗНЕВОДНЕННЯ

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***Keywords**: convective, combined drying, apples, energy efficiency, duration of drying, Rebinder number, recoverability.*

ABSTRACT
The paper examines the intensification of drying apple slices to low residual moisture content. It is proposed to use an energy-efficient multi-stage mode of convective drying at 80/60 °C and a combined multi-stage mode with IR radiation and IR convective heating (100 W) + 60°C / 60°C. The paper presents the temperature and kinetic curves and changes in drying speed for the studied dehydration regimes. A formula was obtained for determining the total duration of the process of drying apple slices using a combined method, and a dependence of the Rebinder number for the studied dehydration modes was constructed. Based on the experimental data analysis and generalization of research results, a method of determining the drying intensity based on the average moisture exchange and the average temperature of material heating per minute, at the first stage of drying and during the entire drying time, was proposed for the first time. The efficacy of the proposed modes is confirmed by a reduction in drying duration 1.9 times compared to the stationary mode at a coolant temperature of 60 °C. The obtained dried product is characterized by high recoverability (78–80%) and appropriate organoleptic properties.

АНОТАЦІЯ
У статті розглянуто інтенсифікацію процесу сушіння яблучних пластинок до низької залишкової вологості. Запропоновано використовувати енергоефективний ступеневий режим конвективного сушіння 80/60 °С та ступеневий комбінований режим з поєднанням ІЧ-випромінювання та конвективного нагріву ІЧ (100 Вт)+60 °С / 60 °С. У статті представлено температурні та кінетичні криві та зміну швидкості сушіння для досліджуваних режимів зневоднення. Одержано формулу для визначення загальної тривалості процесу сушіння яблучних пластинок комбінованим способом, побудовано залежність числа Ребіндера для досліджуваних режимів зневоднення. На підставі аналізу експериментальних даних та узагальненні результатів досліджень вперше запропоновано спосіб визначення інтенсивності сушіння по середній вологовіддачі та середній температурі прогрівання матеріалу за хвилину, на першому етапі сушіння та за весь час сушіння.
Ефективність запропонованих режимів підтверджується скороченням тривалості процесу сушіння у 1,9 рази порівняно з стаціонарним режимом при температурі теплоносія 60°С. Отриманий сушений продукт характеризується високою відновлюваністю (78–80%) та належними органолептичними властивостями.

INTRODUCTION
Drying is a well-known procedure for removing and retaining free moisture, increasing shelf life, and reducing transport weight (*Hany et al., 2022; Bulgakov et al., 2018)*. Apples are the most common type of fruit that is available in the diet throughout the year. They contain a large amount of vitamins such as C, B_1, B_2, P, and E, as well as manganese, potassium, and easily digestible iron. Apples are hypoallergenic and almost everyone can consume them *(Campeanu et al., 2009).*

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Medium-ripe apples with a large amount of aromatic and flavoring substances are suitable for drying. For convenient and quick drying of apples and the possibility of giving them a necessary shape, they are pre-cut into circles, plates, slices, or cubes. As previously shown *(Bessarab and Shutyuk, 2002),* it is advisable to use apples with a diameter of more than 50 mm for drying. Small apples can be used to make more crushed material, but the processing of fruits with a diameter of less than 30...35 mm is impractical due to the increase in waste.

Analysis of recent research and publications

A convective drying method is used at low temperatures of the coolant to dehydrate apples, which is an energy-consuming and long-term process. Therefore, other methods are used for drying, including infrared radiation, high-frequency currents, ultrasound, etc.

One of the effective drying methods for improving the quality of food products and reducing the duration of the drying process is the introduction of heat through infrared radiation. As previously shown *(El-Mesery et al., 2023),* infrared-dried apple slice quality was evaluated experimentally and statistically in terms of the drying period, rehydration ratio, color, and shrinkage as a function of infrared intensity levels, slice thicknesses, and air velocity. Apple slices were dried at infrared intensities of 0.130, 0.225, and 0.341 W/cm2, air velocities of 1.0, 0.5, and 1.5 m/s, and slice thicknesses of 6, 4, and 2 mm. Throughout the procedure, the dried slices were reduced from an initial moisture content of 87.5 %–11 % (w.b.). According to the findings, the drying time needed to decrease the moisture level of sliced apples to roughly 0.12 g water/g dry matter ranged from 200 to 280 min, 170–240 min, and 130–190 min at infrared radiation intensities of 0.130, 0.225, and 0.341 W/cm^2, respectively. Water activity values for dried apple slices ranged from 0.371 to 0.450. The rehydration ratio increased with increasing air velocity and reduced with increased infrared radiation intensity. In contrast, the shrinkage ratio increased with increased infrared radiation intensity and decreased with increased air velocity. Slices of fresh and dry apples had a more significant overall color difference as radiation intensity and air velocity increased.

A study of innovative equipment for drying fruit and vegetable slices under IR radiation conditions was conducted *(Burdo et al., 2018).* An experimental stand and research methodology were developed. The structure of the equation for calculating the mass transfer coefficient was proposed. The base of experimental data was summarized in the equation in similarity numbers. The equation makes it possible to calculate the mass transfer coefficient with an error within +- 15%. The influence of the power of IR radiation on the kinetics of the drying process of fruit and vegetable slices was determined. A comparison of experimental data on the drying of slices under the conditions of microwave and infrared radiation was carried out.

The effect of infrared radiation is quite significant when drying other raw materials as well. Based on experimental studies of grain material dehydration, Bandura, V. et al. (2018) found that under the increase in the power of the IR source from 400 to 500 W, the drying time from the initial moisture content of the material of 11% to 8.75% decreases from 9 to 7 minutes. It was determined that the Rebinder criterion characterizing the moisture-thermal characteristics of the material decreases when reducing its moisture content from 0.04 at 11% to 0.01 at 9%. Microwave energy also has a significant effect on the drying process (Bandura V. et al. (2023)).

There is a known method of drying, according to which apples are dehydrated by a combination of pre-IR treatment and convective drying. Short-term treatment with IR radiation at E = 20 kW/m^2 was carried out for 90 and 120 s. When the process lasts for 90 s, the internal layers of raw materials are heated to the temperature of 70 °C, and when it lasts for 120 s to 82 °C. IR pre-treatment removes up to 15% of moisture within 90 s, and the drying time is reduced by 23%, but when the drying time is 120 s, up to 25% of the moisture is removed with a 62% reduction in the duration of the process compared to only the convective drying method at a coolant temperature of 60 °C. Pre-IR treatment reduces the content of vitamin C in apples to 95%, but due to the reduction of the duration of drying, the content of vitamin C is 65-70%, which exceeds the content of vitamin C when using convective drying by 15-20% *(Snezhkin et al., 2001).*

The use of this drying method is not advisable, since the maximum allowable temperature of the material is exceeded, which is a determining parameter when drying plant heat-labile raw materials.

The purpose of this research is to intensify the process of drying apple slices to low residual moisture content without losing biologically active substances of fresh raw materials.

To achieve the goal, it is necessary to solve the following tasks:

- to establish kinetic regularities of the process of drying apple slices by convective and combined methods;
- to develop dehydration modes using a combined drying method;
- to investigate the intensity of the developed drying methods;
- to calculate the total duration of the drying process of apple slices using a combined method of dehydration;
- to determine the criterion for optimizing the drying process;
- to evaluate the recoverability and organoleptic indicators of the obtained dried product.

MATERIALS AND METHODS

The investigation of the process of dehydration of apples aimed at studying the main patterns of heat and mass transfer was carried out on the experimental drying stand, the schematic diagram of which is shown in Fig. 1 *(Paziuk et al., 2018).*

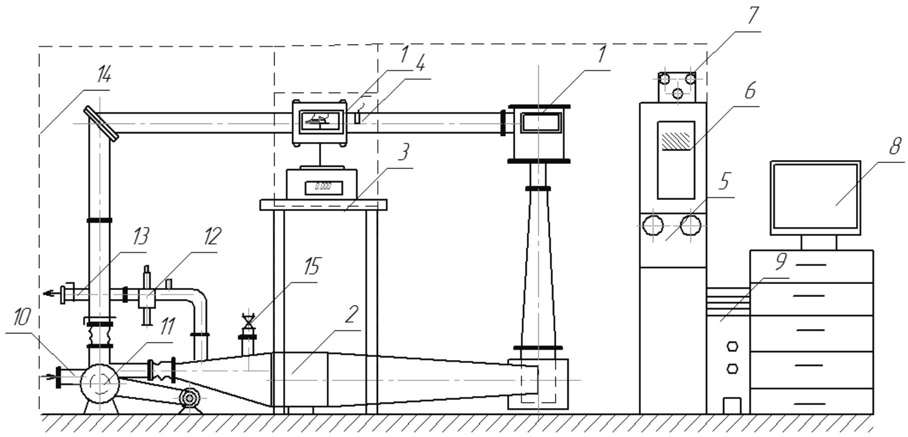

Fig. 1 - Scheme of an experimental drying stand for the study of heat and mass exchange processes during dehydration of apples

1 – drying chambers; 2 – air heating section; 3 – scales with a stand; 4 – resistance thermometer; 5 – control panel; 6 – potentiometer; 7 – air temperature regulator; 8 – monitor; 9 – workstation system unit; 10 – nozzle for mixing the coolant with ambient air; 11 – fan; 12 – psychrometer; 13 – air discharge nozzle for subsequent mixing; 14 – thermal insulation frame; 15 – a steam supply nozzle with a needle valve

The experimental stand consists of a system of insulated air ducts with devices for heating and circulation of the coolant, drying chambers, a system for controlling the temperature of the coolant, automatic collection and processing of information about the course of the material dehydration process.

The air heating section (2) is made in the form of a rectangular box, in which a three-section electric heater with a capacity of 10 kW is placed. To ensure accurate maintenance of the set temperature, the heater is connected to an automatic regulation system and TSM-50 resistance thermometers (4). It enables to maintain the temperature of the coolant in automatic mode with an accuracy of ±0.1°C.

The movement of the coolant occurs with the help of a centrifugal fan (11) of medium pressure. Changing the speed of the coolant is achieved by adjusting the frequency of rotation of the fan (11) on the control panel (5). The ratio between exhaust and fresh air can be adjusted with the help of dampers on the nozzles (10) and (13). The air velocity in the drying chambers was measured using an anemometer MS-13.

The stand is equipped with an automated system for information collection and processing, which includes a computer, AD-500 digital scales, a specially developed automated program, a temperature measurement channel consisting of an analog-digital converter, and an interface. Analog signals from thermoelectric sensors were converted into digital form by an ADC (i-7018) and transmitted to a computer using an interface (i-7520).

Experimental studies of drying apples were carried out in the following sequence:

1. Choosing a variety of apples. The selected variety of Jonagold apples has a red color and a balanced sweet taste (yield of 2023, harvested in Vinnytsia region, Ukraine).

2. Preparation of apples for drying. Apples were washed under running water and cut into slices 4...5 mm thick, 8...10 mm wide, and 60...65 mm long, with seeds removed.

3. Drying apple slices to a low residual moisture content of 5%.

4. Based on the experimental data, there were constructed drying kinetics curves $W = f(\tau)$, drying speed curves $dW/d\tau = f(W)$, obtained by numerical differentiation of drying curves, as well as material heating temperature curves $\theta = f(\tau)$.

5. To determine the quality of the obtained product and check the correctness of the developed dehydration regimes, a study was conducted to determine the coefficient of swelling and recoverability according to the methodology given in the publications *(Husarova, 2020).*

Since long-term thermal action negatively affects the quality of dried apple products, the main emphasis should be made on using the maximum allowable temperatures of the material and reducing the duration of the process when developing dehydration regimes.

The maximum permissible temperature for heating apples, as a rule, does not exceed 60 °C and is determined *(Husarova, 2020)* by the following items:

1) thermosensitivity of the protein complex;

2) thermal decomposition of sugars, which is accompanied by the formation of dark-colored substances;

3) reactions of non-enzymatic darkening during the interaction of sugars with amino acids.

Dehydration of apple slices was carried out by two methods of drying:

- convective – using stationary (60, 80 °C) and multi-stage (80/60 °C) modes;
- combined multi-stage infrared-convective mode – IR (100 W) + 60 °C / 60 °C.

Multi-stage convective drying was carried out as follows: at the beginning of the process, the temperature of the coolant was 80 °C, as the material warmed up to 55 °C, the temperature of the coolant was lowered to 60 °C, and it maintained at this level until the end of the process.

Combined multi-stage infrared-convective drying consists of two stages: the first one is a combined drying at IR (100 W) + 60 °C, and the second one is a convective drying at 60 °C. In the first stage, drying takes place with a combination of two methods of drying, in particular, IR and convective drying, and when the material reaches a temperature of 59 °C, IR radiation is turned off, and then only convective dehydration takes place at the temperature of 60 °C.

RESULTS

Intensification of the process of drying apple slices due to multi-stage convective dehydration

Determination of the duration of drying apple slices was carried out at coolant temperatures of 60, 80, 80/60 °C (Fig. 2).

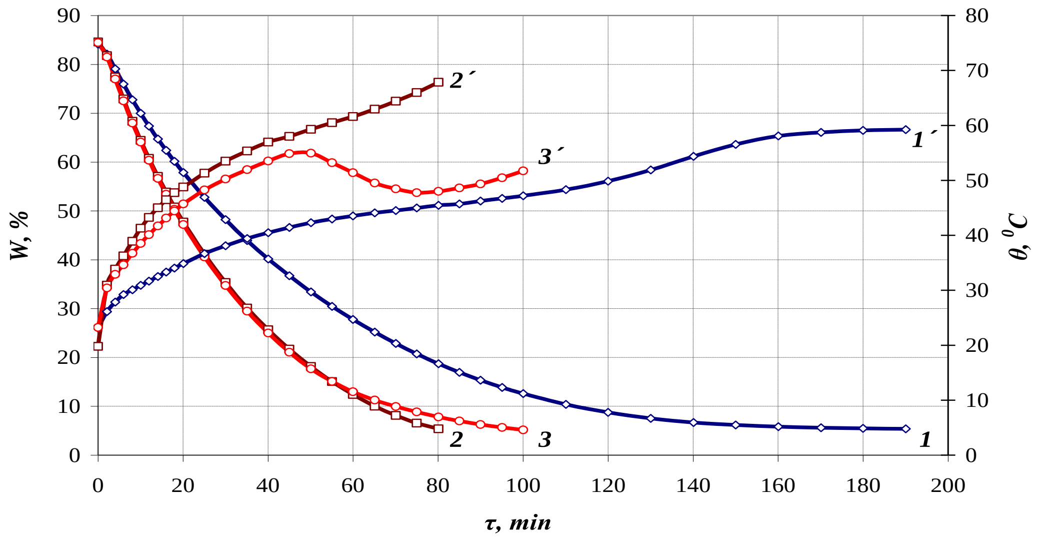

Fig. 2 - Influence of a coolant temperature on the kinetics of the process of drying apple slices with dimensions of 5×10×65 mm, *V*= 1.5 m/s, *d* = 10 g/kg of dry air: *1, 1´ – 60 °C; 2, 2´ – 80 °C; 3, 3´ – 80/60 °C*

An increase in the temperature of the coolant from 60 to 80°C (curves 1, 2) reduces the drying time by 2.38 times. Drying was carried out from the initial relative moisture content of 84% to the final moisture content of 5%.

According to curve 2´, under a coolant temperature of 80°C, the final temperature of heating the material reached 68.2°C, which was higher than the permissible level of 60°C, so the coolant temperature must be reduced.

Using a multi-stage drying mode of 80/60°C is suggested. In the first stage, which lasts for 50 minutes, this mode intensifies the process due to the use of a drying temperature of 80°C, which ensures intensive removal of most moisture from the material (curves 3, 3´). Then, when the material reached a current moisture content of 18% and was heated to 55°C, the temperature of the coolant was lowered to 60 °C and maintained at this level throughout the second stage of drying until the end of the process.

In this case, the drying time increases to 100 min compared to the 80°C drying mode (curves 2, 3), but the final heating temperature in the middle of the material does not exceed 51.7°C, which is 16.5°C less (curve 2´, 3´) and guarantees compliance with the maximum temperature of raw material.

Compared to the stationary mode of dehydration at 60°C (curve 1), the duration of the process is reduced by 90 minutes.

The use of a multi-stage mode of 80/60 °C preserves biologically active substances in dried apple slices and intensifies the drying process.

To characterize the drying process, curves of the drying speed of apple slices were constructed (Fig.3). The drying process takes place in the period of falling drying speed.

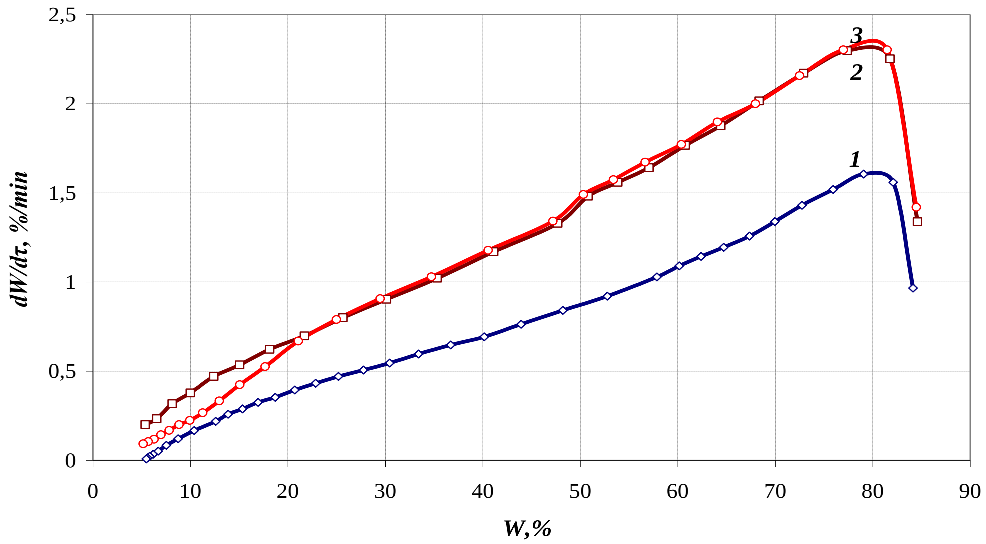

Fig. 3 - Influence of the coolant temperature on the speed of drying apple slices with dimensions of 5×10×65 mm, *V*= 1.5 m/s, *d* = 10 g/kg of dry air
1 – 60°C; 2 – 80°C; 3 – 80/60°C

According to Fig. 3, in the 80 and 80/60 °C drying modes (curves 2, 3), the maximum speed values are 2.3%/min, which is 1.43 times higher than in 60°C drying mode (curve 1). The decrease in the intensity of drying at the end of the process in the multi-step mode of 80/60°C is associated with a decrease in the temperature of the coolant to the level of the maximum permissible temperature for heating the raw material.

Intensification of the process of drying apple slices by a multi-stage combined infrared-convective method (IR radiation E= 3.8 kW/m^2)

According to Fig. 4, the use of a multi-step combined drying mode IR (100 W) + 60°C / 60°C compared to the stationary mode of 60°C (curves 1, 3) allows to reduce the duration of the process by 90 min or 1.9 times. A comparison of two-step, convective, and combined modes (curves 2, 3) indicates that the duration of drying is the same and lasts 100 minutes. These curves have different nature, and to analyze the intensity of drying apple slices, an additional analysis is required, which is given below and shown in Fig. 5-7.

Temperature curves 1´– 3´ describe the nature of the process of drying apple slices (Fig. 4). At a coolant temperature of 60 °C (curve 1´) the drying process proceeds slowly, with a gradual increase in the temperature of the material to 59.2 °C and long-term uniform removal of moisture from the material.

The difference between the multi-step combined drying mode IR (100 W) + 60°C / 60°C and the 80/60°C multi-stage convective drying mode is that heating occurs faster, already at the 35th minute, until the material reaches the temperature of 59°C (curve 3´, point C). The final temperature of heating the material in the combined mode is higher than that one in the convective mode and reaches 56°C.

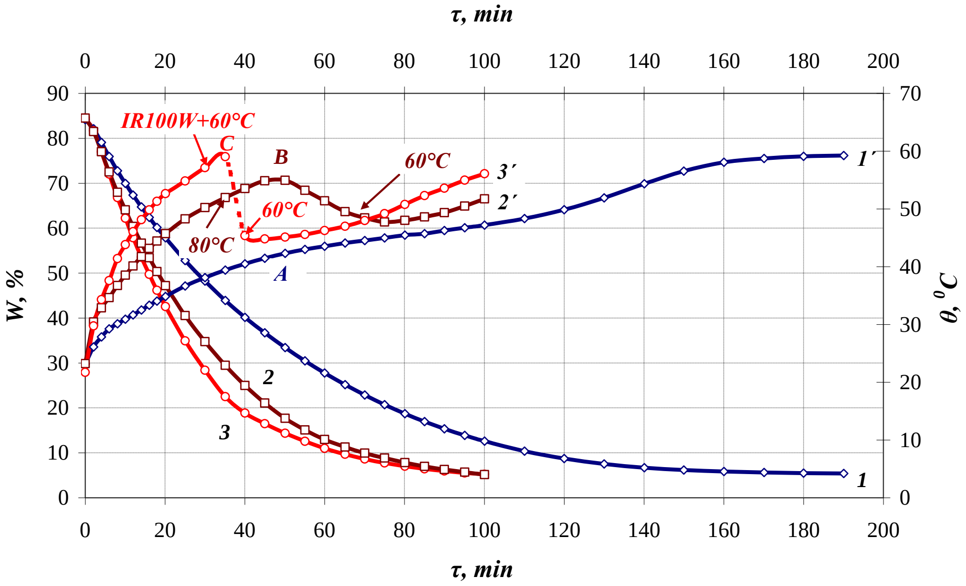

Fig. 4 - Influence of the drying modes on the kinetics of the process of dehydrating apple slices with dimensions of 5×10×65 mm, *V*= 1.5 m/s, *d* = 10 g/kg of dry air

1, 1´ – 60 °C; 2, 2´ – 80/60 °C; 3, 3´ – IR (100 W)+ 60 °C / 60 °C. A, B, C are points of comparison and changes in drying modes

The intensity of the process of drying apple slices shown in Fig. 5 is estimated by the values of the maximum drying speed.

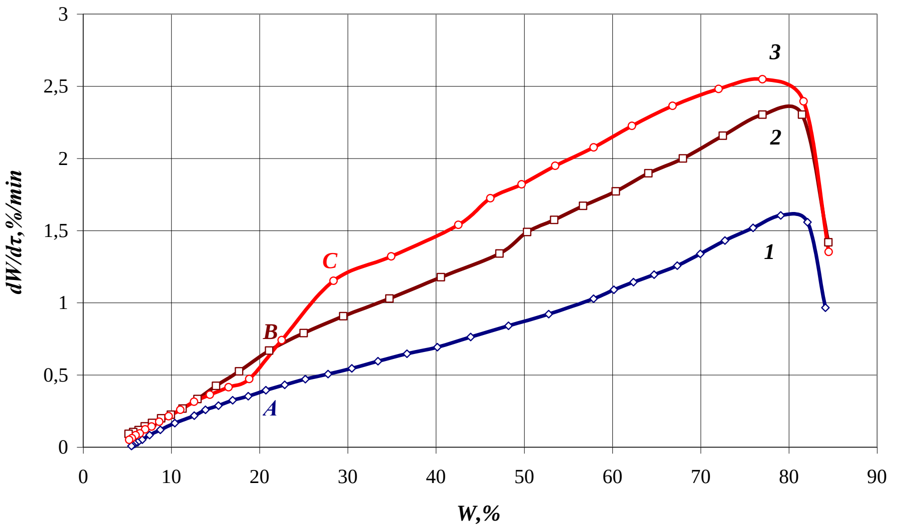

Fig. 5 - Influence of drying modes on the speed of dehydrating apple slices with dimensions of 5×10×65 mm, *V*= 1.5 m/s, *d* = 10 g/kg of dry air

1 – 60 °C; 2 – 80/60 °C; 3 – IR (100 W) + 60 °C / 60 °C. A, B, C are points of comparison and changes in drying modes

Thus, the combined IR drying mode (100 W) + 60 °C / 60 °C (curve 3) is the most intense. It enables to increase a maximum speed compared to the drying mode of 60 °C by 1.58 times, and the multi-stage mode of 80/60 °C by 1.1 times.

When applying a multi-stage combined infrared-convective mode (curve 3, Fig. 5), a decrease in the drying speed is observed when the material reaches a moisture content of 23% (point C), which is associated with turning off the IR radiation and a sharp drop in the temperature of the material. Due to this, both multi-step modes have the same drying time.

Study of the kinetics of the process of dehydrating apple slices, determination of the drying process duration

To study the kinetics of drying apples by the combined infrared-convective method, the drying kinetics curve in semi-logarithmic coordinates lgW – *(N·τ)* will be presented in Fig. 6 *(Paziuk et al., 2021)*.

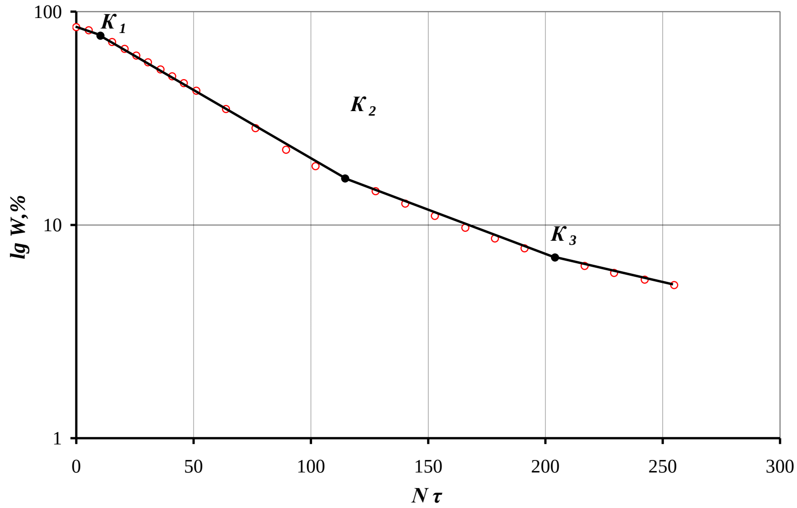

Fig. 6 - The curve of kinetics of drying apple slices with dimensions 5×10×65 mm, V= 1.5 m/s, d = 10 g/kg of dry air in coordinates lg*W* – (*N·τ*)

In the mathematical description of the kinetics of moisture exchange during drying in the second period, it is necessary to consider empirical coefficients (K_i), which are substantiated by the properties of this material. These coefficients are determined directly according to the experiment on drying.

The relative drying coefficient χ_i is determined only by the form of moisture connection with the material, its structure, density and does not depend on the processing mode.

The values of the relative drying coefficients of apple slices in the second period are determined according to the formulas (1 - 3):

$$\chi_1 = \frac{\lg W_{К_1} - \lg W_{К_2}}{N\tau_1} = \frac{\lg 77 - \lg 16.49}{104.3} \approx 0.0064 \quad (1)$$

$$\chi_2 = \frac{\lg W_{К_2} - \lg W_{К_3}}{N\tau_2} = \frac{\lg 16.49 - \lg 7}{89} \approx 0.0042 \quad (2)$$

$$\chi_3 = \frac{\lg W_{К_3} - \lg W_{К}}{N\tau_2} = \frac{\lg 7 - \lg 5.22}{50.8} \approx 0.0024 \quad (3)$$

The drying coefficients in the second drying period are determined by the dependences (4 -5):

$$K_1 = \chi_1 \cdot N = 0.0064 \cdot 2.54 \approx 0.0163\,\text{хв}^{-1} \quad (4)$$

$$K_2 = \chi_2 \cdot N = 0.0042 \cdot 2.54 \approx 0.0107\,\text{хв}^{-1}. \quad (5)$$

$$K_3 = \chi_3 \cdot N = 0.0024 \cdot 2.54 \approx 0.0061\,\text{хв}^{-1} \quad (6)$$

The total duration of the process is determined by the dependence (7):

$$\tau_T = \frac{1}{N}\left(\frac{1}{\chi_1}\lg\frac{W_{К_1}}{W_{К_2}} + \frac{1}{\chi_2}\lg\frac{W_{К_2}}{W_{К_3}} + \frac{1}{\chi_3}\lg\frac{W_{К_3}}{W_{К}}\right) \quad (7)$$

Having substituted the values of relative drying coefficients χ_i and critical moisture content $W_{К_i}$, the total duration of the drying process is obtained:

$$\tau_T = \frac{1}{2.54}\left(\frac{1}{0.0064}\lg\frac{77}{16.49} + \frac{1}{0.0042}\lg\frac{16.49}{7} + \frac{1}{0.0024}\lg\frac{7}{5.22}\right) \approx 97\,\text{min}$$

According to experimental data, drying lasts100 minutes under the combined mode, i.e. the deviation of the experimental value from the theoretical one is 3%.

The study of the process of heat and mass transfer when drying apple slices

To describe the process of heat and mass transfer when drying apple slices, the Rebinder number will be used. The Rebinder number is equal to the ratio of the amount of heat required to heat the material to the amount of heat required to evaporate moisture from it during an infinitesimally small time period. It is also called a criterion for optimizing the drying process.

$$Rb = b\frac{c}{r} \tag{8}$$

where:

b – temperature coefficient of drying; c – specific heat capacity of the material, kJ/kg K;

r – specific heat of moisture evaporation, kJ/kg.

The temperature coefficient of drying b is the derivative of the average temperature of the material θ from the moisture content of the material W:

$$b = \frac{d\overline{\theta}}{d\overline{W}} \tag{9}$$

Analysis of the Rebinder number during drying of apple slices, under the studied dehydration modes, shows that the process of heat and mass transfer is initially inefficient, most of the energy is spent on heating the material, and not on evaporating moisture from it (Fig. 7).

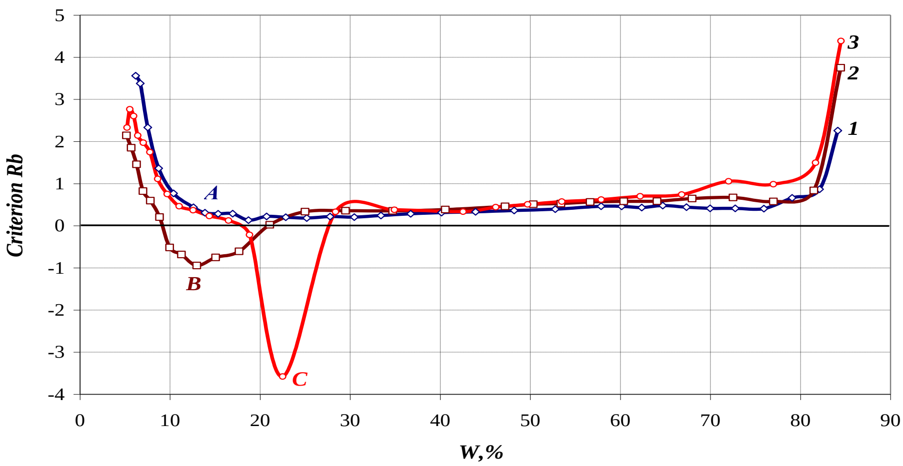

Fig. 7 - Influence of the drying mode on the change in the Rebinder number when drying apple slices with dimensions of 5×10×65 mm, *V*= 1.5 m/s, *d* = 10 g/kg of dry air

1 – 60 °C; 2 – 80/60 °C; 3 – IR (100 W) + 60 °C / 60 °C

A, B, C – points of comparison and change of drying mode

The heat and mass exchange process for each drying mode will be considered separately, as they have their own characteristics.

For the drying mode of 60°C (curve 1), at the beginning of the process, the material is heated (to 75% moisture content), then moisture evaporates from the material (to 14% moisture content and then the material begins to warm up, which is not efficient and indicates economic feasibility of completion of the drying process at 14% moisture content at point A.

For the multi-stage convective mode of 80/60°C (curve 2), at the beginning of the process, the material is actively heated (up to 82% moisture content), then moisture evaporates from the material (up to 18% moisture content), the first stage of drying is completed at a coolant temperature of 80°C, then the material heating temperature decreases to point B. After point B, the material is heated again and the process changes from effective to ineffective. In this mode, effective drying of apple slices (close to zero) can be carried out to a moisture content of 8.8%.

For the multi-stage combined infrared-convective drying mode (curve 3), at the beginning of the process, the material is actively heated (up to 77% moisture content), then moisture evaporates from the material (up to 23% moisture content), then the first stage of drying in the IR mode (100 W) +60°C, the temperature and the Rebinder criterion drop sharply to point C. This is due to the shutdown of IR radiation. Then the heating of the material begins again at a coolant temperature of 60°C. It is economically expedient to carry out drying to point A, as in the 60°C mode, to a final moisture content of 14%.

Investigation of quality characteristics of apples

Swelling capacity is one of the quality criteria of dried products.

The complete recovery of dried apples is not observed, due to the fact that during drying the material shrinks, the structure of parenchymal tissues is deformed, and free intercellular spaces through which water is absorbed are compressed. As a result of heat exposure, substances that normally bind water and swell are subjected to irreversible denaturation *(Husarova, 2018; Husarova, 2020; Husarova et al., 2020).*

The highest value of recoverability is observed under multi-stage drying modes 78-80% (Fig.8).

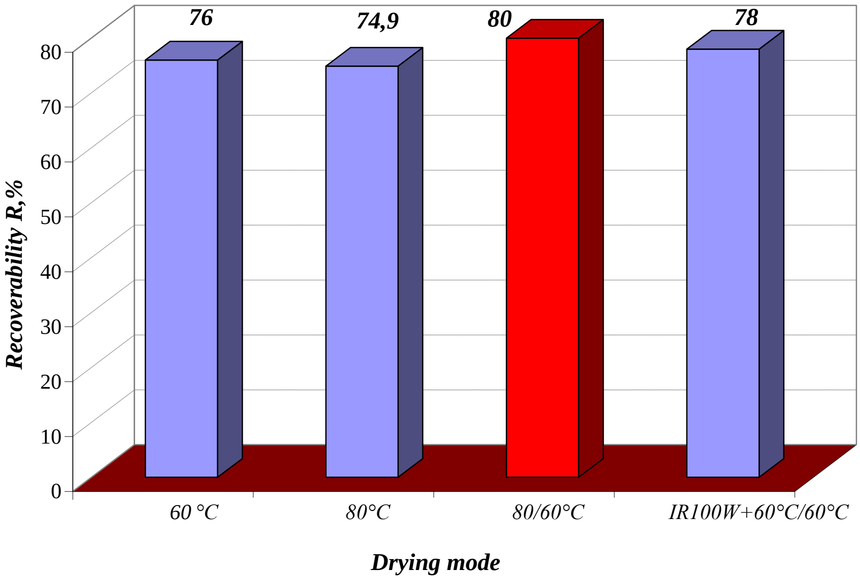

Fig. 8 - Dynamics of changes in the recovery of dried apple slices with dimensions of 5×10×65 mm under different drying modes, *V* = 1.5 m/s, *d* = 10 g/kg of dry air

Organoleptic indicators of the dried slices obtained under a dehydration mode of 80/60 °C and combined IR (100 W) + 60°C / 60°C were as follows: balanced taste, natural aroma, and light cream color inherent to the raw material. Apple slices obtained under a stationary mode of 60 °C had a less pronounced aroma of fresh apples and acquired a yellowish color. This is explained by the long process of dehydration, which leads to reactions of enzymatic darkening of samples and destruction of biologically active substances present in the raw material.

CONCLUSIONS

Summarizing the research results, it can be concluded that a high temperature of the coolant ensures an insignificant duration of the dehydration process, but organoleptic indicators of the finished product are unacceptable.

Drying at low temperatures leads to an increase in dehydration time, and as a result, to an increase in energy consumption and deterioration of organoleptic characteristics and recoverability.

The following results were obtained during the accomplishment of the assigned tasks:

1. To intensify dehydration, reduce energy costs, and ensure a reduction in the duration of drying, the process must be carried out according to the developed modes of convective drying 80/60 °C and combined infrared-convective drying IR (100 W) + 60°C / 60°C.

2. The intensity of the proposed multi-stage drying modes is confirmed by a 1.9-fold reduction in the duration of the process compared to the stationary mode at a coolant temperature of 60°C.

3. Based on the studies of the kinetics of moisture exchange in the combined mode of drying apples, a formula for calculating the total duration of the process was obtained. The difference between the experimental and theoretical values of the drying time does not exceed 3%.

4. Dependencies of the Rebinder number for different modes are constructed, which prove the expediency and effectiveness of using the developed multi-stage dehydration modes.

5. Under the developed multi-stage drying modes, the obtained product had high recoverability (78-80%) and organoleptic indicators, namely, balanced taste, natural aroma, and light cream color inherent to the raw material.

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