АУЫЛ ШАРУАШЫЛЫҒЫН МЕХАНИКАЛАНДЫРУ ЖӘНЕ ЭЛЕКТРЛЕНДІРУ
МЕХАНИЗАЦИЯ И ЭЛЕКТРИФИКАЦИЯ СЕЛЬСКОГО ХОЗЯЙСТВА
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INFLUENCE OF TECHNOLOGICAL PARAMETERS ON THE TEMPERATURE-TIME MODES OF VACUUM FREEZE-DRYING OF THE PRODUCT

Abstract

The process of sublimation drying of berries provided, this is the drying method along the berry the humidity is reduced to 2-5%. The dryer is conditional consists of two blocks - refrigeration and sublimation unit. At room temperature the product is placed in the drying chamber. Equipment after connection, vacuum pump in the chamber reduces the pressure to 10-30 Pa. When a vacuum is created and free product due to evaporation of moisture leads to freezing. Most of the moisture is converted into ice crystals, and then the sublimation process begins. This equipment uses 404 a freon. Temperature to register 8 channel OVEN TRM138 RS-485 temperature meter was used. Of the product to measure weight every 30 minutes removed from the chamber Vibra HT 224RCE was weighed on an analytical balance. The experiment was performed with three types of berries: strawberries; currants and raspberries. Experience during the temperatures on the surface of the berries, inside the chamber and the mass of the product were measured. Duration of drying as a criterion of effective mode, energy expenses and quality indicators of dried berries were determined. The effective sublimation time was 4.5 hours. Inside the chamber at a pressure of (20 ± 5) Pa, at a temperature of (-42 ± 2) ^{0}C, general freezing and sublimation time not more than 5 hours, the total drying time is 8 hours. The initial weight of strawberries decreased by 36%, currants by 28% and raspberries by 27.4%. Drying should be stopped when the chamber temperature reaches 40 ° C.

Key words: *sublimator, automation, algorithm, pressure sensor, temperature sensor, solar collector, generator, control panel, vacuum pump, generator.*

Introduction

The purpose of this work is to study the process of sublimation drying of berries. This drying method is the most effective than other. Reducing the humidity along the berries to 2-5%, low-humidity products can be stored for a long time in places where the temperature is not. This drying method can preserve the useful properties of the product for a long time. The mass is reduced, the original volume is preserved and the color is preserved. Sublimation drying is divided into two types: Drying is very slow at low temperatures and. Therefore, it is vacuumed to speed up the drying process [9, 12]. A decrease in pressure leads to an increase in the intensity of evaporation due to an increase in the mass transfer coefficient. Vacuum drying is performed inside a hermetically sealed apparatus, so no heat is transferred from. Therefore, vacuum drying provides heat to the product (through heating elements, infrastructure, etc.). Basically, the sublimation process consists of three stages: freezing, sublimation and drying. In the first stage, the temperature of the product is lowered to the freezing point, which causes the formation of ice crystals inside the product. Then there is the process of sublimation, during which the ice evaporates. The impact of this stage has a direct impact on product quality. It should be noted that the initial freezing period must be frozen as soon as possible, so that the formed ice crystals evaporate quickly. The final drying takes place at a temperature not exceeding + 40^{0}C [6, 11]. The berries are capillary-porous bodies and colloidal in nature.

They are characterized by the properties of capillary-porous and colloidal bodies. Their walls are elastic and swell when they absorb fluid. Their bodies absorb fluid shrinks, brittle so you can turn it into a powder. When removing moisture from the material, the amount of moisture in it and wet material corresponds to the connection. Moisture contact with the material isothermal dehydration characterized by the amount of free energy - moisture in the given substance constant without changing the composition 1 mol of water at room temperature work to lose [1, 2, 5]. Moisture contact with the material isothermal dehydration characterized by the amount of free energy - moisture in the given substance constant without changing the composition 1 mol of water at room temperature work to lose. In the case of free moisture in the material, the binding energy is 0. As the amount of moisture decreases, its bond with the material increases and the binding energy increases. As the moisture content of the material decreases, the binding energy increases. Wet materials heat treatment or heat when exposed to moisture, moisture begins to change its physical properties. These changes of a molecular nature associated with the fluid absorbed by the body of the substance [3, 4, 7, 8].

At the same time, absorbed fluid or capillary-porous body inside steam transport body fluids and body skeleton corresponds to the nature of the molecular bond between. P.A. Raider on all communication types chemical bond, physicochemical bond, physico-mechanical bond are divided into three main groups. In food of the above types of communication everything is there, however, the product dries only a few species play an important role. Mechanical connection of water is weak, it is maintained only by the filling of macro and microcapillaries. Use it as a free moisture can be considered, during sublimation drying. Physicochemical the connections are strong. Adsorption on it and includes osmotically bound moisture, it is removed. Chemical bond the strongest connection is, chemically associated water drying will not be deleted during. As a form of drying berries, they have a lot of water, the amount of dry matter will be less. The bulk of the water is free and is bound to 5% of cell colloids and is firmly in place. The chemical composition of berries consists of carbohydrates, proteins and lipids. Along with them albeit to a lesser extent contains biologically active substances, they taste raw and determines the biological value, these include polyphenols, vitamins, organic acids and minerals. In table 1 below in this work used berries containing nutrients the dimensions are given [9, 10, 12].

Table 1. Berries nutrient composition

Berries	Nutrients, g / 100 g			Calories, kcal/100 g
	water	carbohydrates	protein	
Cherry	83,0	12,0	0,5	62,0
Black currant	82,0	13,0	1,0	59,0
Raspberry	84,2	10,2	1,0	45,9

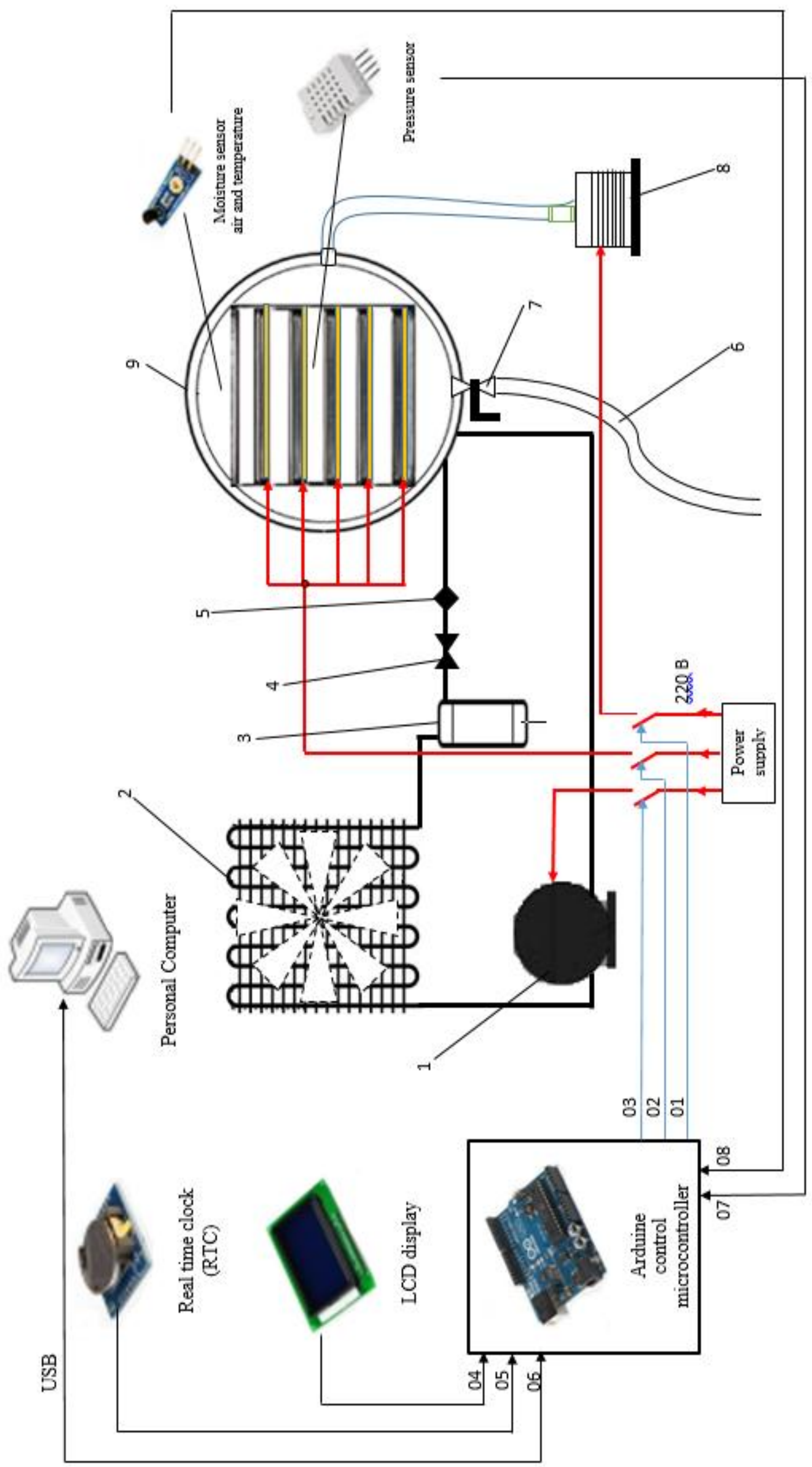
Materials and methods. In this work, an updated version of the dryer, developed by scientists of the Department of "Energy Saving and Automation" of the National Agrarian Research University of Kazakhstan. This is drying device chambers the layout was changed and micanite heating elements were used. Of the device the appearance is shown in Figure 1.

The dryer is conditional consists of two blocks - refrigeration and sublimation from the device.The principle of operation is as follows. At room temperature, the product is placed in the drying chamber. After switching on the unit, the vacuum pump reduces the pressure in the chamber to 10-30 Pa. When a vacuum is created and due to evaporation of free moisture leads to freezing of the product. Most of the moisture transformed into ice crystals, then the sublimation process begins. Humidified steam vacuum under the influence of the pump comes to the desublimator, where the moisture turns to ice sticks to the surface of the desublimator. The air in the desublimator is vented. Drying process in the final stage micanite heating of the product the remaining moisture is removed by the elements. On the device and so on in the desublimator ice defrosting is provided. To do this, open the solenoid valve, then the hot vapor of the refrigerant come to the evaporator melts the ice in it. This device uses 404 a freon. Of the device the schematic diagram is shown in figure 2. 8-channel OVEN TRM138 RS-485 temperature for temperature recording meter was used. Weighing the product for every 30 minutes removed from the camera Vibra HT 224RCE analytical balance. The experiment was performed with three types of berries: strawberries; currants and raspberries. During the experiment, the temperatures on the surface of the berries, inside the chamber and the mass of the product were measured. Drying as a criterion for an efficient regime duration, energy costs and dried the quality of the berries indicators were determined.

Figure 1. "Alaman" vacuum sublimation dryer appearance

Results and their discussion

Based on the obtained data graphs were constructed. In Figures 3 and 4 below the time dependence of the temperature on the surface of the products and in the middle of the chamber. In the graphs, the whole drying process is divided into three stages. The first stage is the freezing of the product, so you can see in graph 1 that the temperature of the product has dropped. In the second stage, you can see that the temperature of the product is falling. After 2 hours of the drying process an effective temperature of -20 ...- 300C is set on the surface of the product, at the same time the temperature in the middle of the product was falling and reached the required level after 5 hours, it can be seen in figure 2. The effective sublimation time was 4.5 hours. After that heat transfer to the product in 3 stages drying was performed. This is the trend in graphs product temperature characterized by a gradual rise. Figure 4 shows the dependence of the strawberry mass on the drying time. In the first stage, the product temperature does not change. From the second stage the mass begins to decrease, ie 57% humidity was obtained. The remaining moisture was obtained in the third stage by artificial heating. The total drying time was 8.5 hours. The initial weight of strawberries decreased by 36%, currants by 28% and raspberries by 27.4%.



1 – compressor; 2 – condenser with fan; 3 – receiver; 4 - expansion valve; 5 – filter drier;
6 – vacuum hose; 7 – drain tap; 8 – vacuum pump; 9 – desublimator evaporator.

Figure 2 - Scheme of the implementation of the automatic control system for vacuum freeze-drying equipment

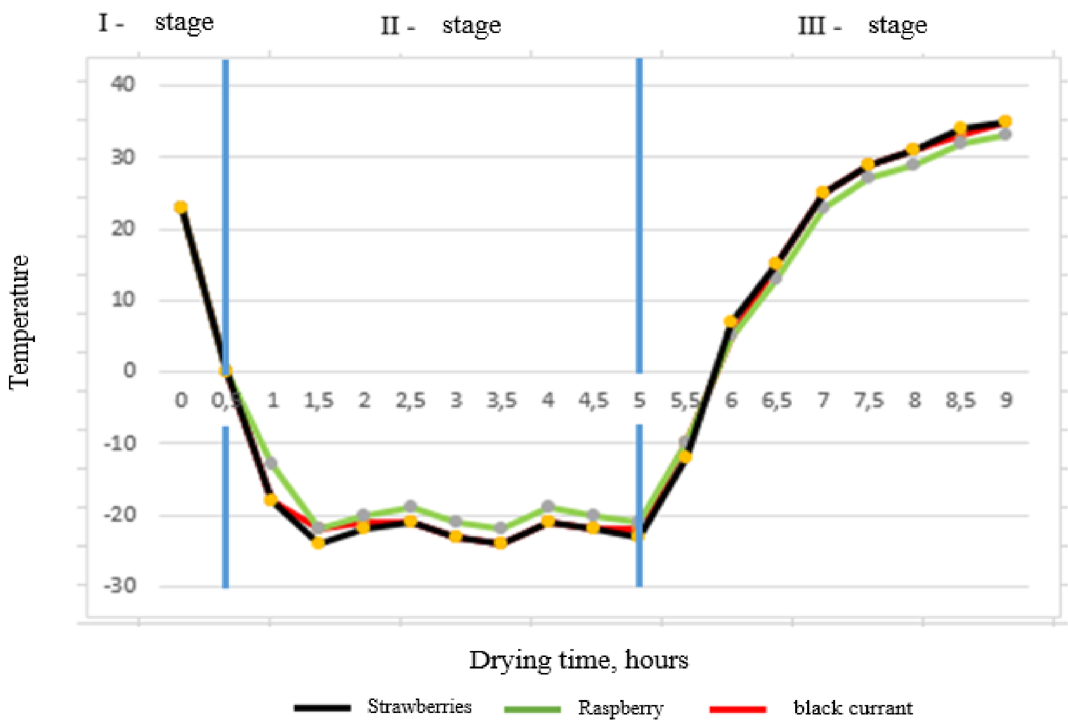


Figure 3. Time dependence of the surface temperature of the products inside the chamber

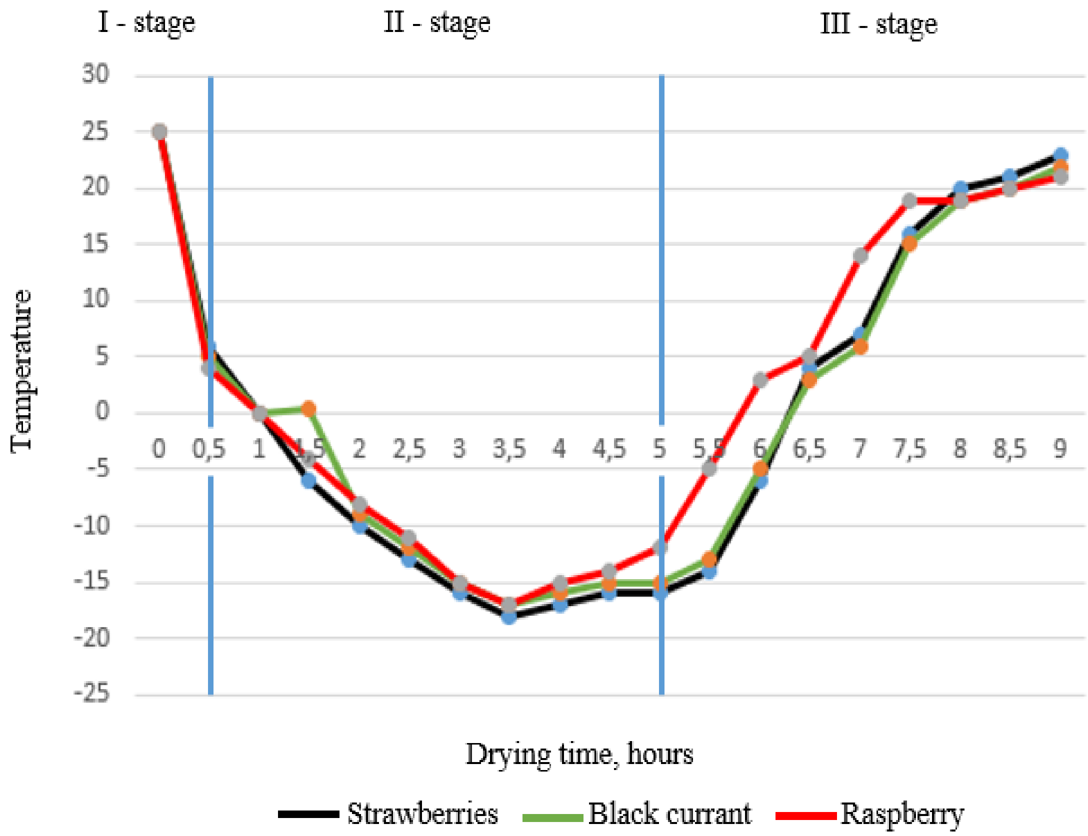


Figure 4. Time dependence of the temperature in the middle of the chamber where the products are located

In figures 5 and 6 in the drying chamber and evaporator temperature curves are shown. As shown in Figure 1 chamber temperature in the 1st stage, at a level below 100C in all work processes. It is in a vacuum convective heat transfer components with a decrease explained. Evaporator temperature decreases to -42^{0}C. After 2 hours in the sublimation stage after the start of drying, the process becomes stationary and so on evaporator temperature -41 ....- 43^{0}C level. On camera ice after sublimation, the temperature begins to gradually decrease to -12^{0}C. After switching on the heating, the drying curve in figure 1 rose sharply. The temperature rise is shown in figure 7, but the temperature equalization is based on the fact that more coolant enters the evaporator based on the automatic stabilization system. After 8 hours of drying, the temperature in the chamber reaches 42^{0}C due to the drying process.

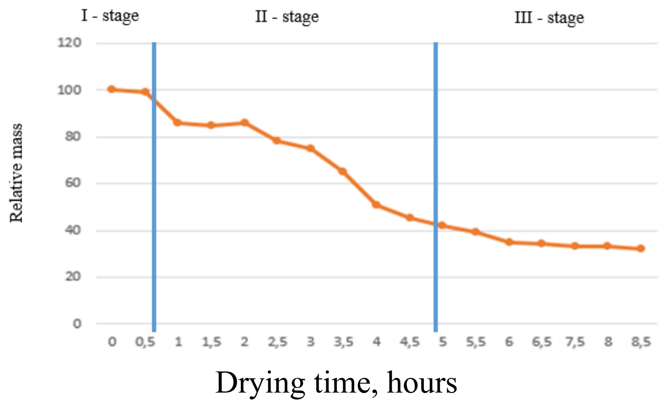


Figure 5. Dependence of strawberry mass on drying time

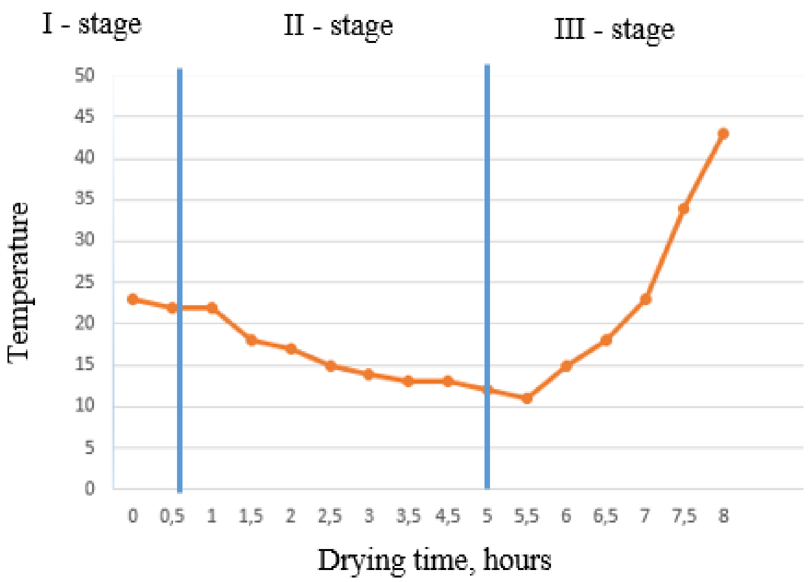


Figure 6. Dependence of chamber temperature on drying time

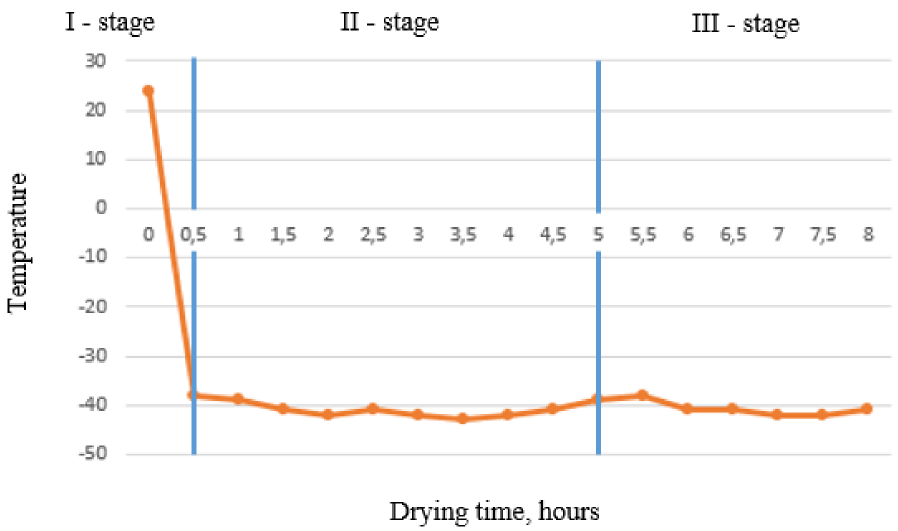


Figure 7. Dependence of evaporator temperature on drying time

Conclusion

This is the work done as a result, is to determine the effective time regimes of dried berries. The results of the work can be concluded as follows, (20 ± 5) Pa pressure (-42 ±2) ^{0}C, total freezing and sublimation time not more than 5 hours, total drying time 8 hours. Temperature during sublimation on the surface of the product (-25 ± 5) ^{0}C should be limited. Drying should be stopped when the chamber temperature reaches 40^{0}C, the surface temperature of the product. An effective sublimation regime is the complete pre-freezing of the product, in the form of ice vapor during sublimation uniform output and uniform drying process. The duration of sublimation drying depends on the thickness of the product, freezing temperature, physical and chemical properties. The duration of sublimation drying depends on the thickness of the product, freezing point, physical and chemical properties.

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ВАКУУМДЫҚ СУБЛИМАЦИЯЛЫҚ КЕПТІРУДІҢ РЕЖИМДЕРІНЕ ТЕХНОЛОГИЯЛЫҚ ПАРАМЕТРЛЕРДІҢ ӘСЕРІ

Аңдатпа

Мұздату-сублимациялық кептіру кезінде жемістердің ылғалдылығы 2-5% дейін төмендейді. Кептіргіш екі блоктан тұрады: тоңазытқыш және сублимациялық. Өнім бөлме температурасында кептіру камерасына орналастырылады. Құрал қосылғаннан кейін вакуумдық сорғы кептіру камерасындағы қысымды 10-30 Па-ға дейін төмендетеді. Вакуум пайда болып, өнімдегі бос ылғал буланып, қатып бастайды. Ылғалдың көп бөлігі мұз кристалдарына айналады, содан кейін сублимация процесі басталады. Бұл жабдықта 404a фреоны қолданылады. «Температураны тіркеу үшін RS-485 интерфейсі бар 8-арналы OVEN TRM138 термометрі қолданылды. Өнім камерадан шығарылғаннан кейін әр 30 минут сайын Vibra HT 224RCE аналитикалық таразыларында өлшенді. Эксперимент үш түрлі жемістермен жүргізілді: құлпынай, қарақат және таңқурай. Эксперимент барысында жемістердің беткі температурасы, камера ішіндегі температура және өнімнің массасы өлшенді. Кептіру ұзақтығы тиімді режимнің, энергия шығынының және кептірілген жемістердің сапалық көрсеткіштерінің критерийі ретінде анықталды. Тиімді сублимация уақыты 4,5 сағатты құрады. Камераның ішіндегі қысым (20 ± 5) Па және температура (-42 ± 2) °C кезінде мұздату және сублимацияның жалпы уақыты 5 сағаттан аспады, ал жалпы кептіру уақыты 8 сағатты құрады. Құлпынайдың бастапқы массасы 36% -ға, қарақаттың массасы 28% -ға және таңқурайдың массасы 27,4% -ға азайды. Кептіру камерадағы температура 40 °C-қа жеткенде тоқтатылуы керек.

Кілт сөздер: сублиматор, автоматтандыру, алгоритм, қысым датчигі, температура датчигі, күн коллекторы, генератор, басқару панелі, вакуумдық сорғы, генератор.

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ВЛИЯНИЕ ТЕХНОЛОГИЧЕСКИХ ПАРАМЕТРОВ НА РЕЖИМЫ ВАКУУМНОЙ СУБЛИМАЦИОННОЙ СУШКИ ПРОДУКТА

Аннотация

При сублимационной сушке ягод влажность ягод снижается до 2-5%. Сушилка состоит из двух блоков: холодильного и сублимационного. Продукт помещается в сушильную камеру при комнатной температуре. После подключения оборудования вакуумный насос в сушильной камере снижает давление до 10-30 Па. Вакуум создается, и свободный продукт в результате испарения влаги начинает замерзать. Большая часть влаги превращается в кристаллы льда, после чего начинается процесс сублимации. В данном оборудовании используется фреон 404а. «Для регистрации температуры использовался 8-канальный термометр OVEN TRM138 с интерфейсом RS-485. Продукт взвешивался каждые 30 минут после удаления из камеры на аналитических весах Vibra HT 224RCE. Эксперимент проводился с тремя видами ягод: клубникой, смородиной и малиной. В ходе эксперимента измерялись температуры на поверхности ягод, внутри камеры и масса продукта. Продолжительность сушки была определена как критерий эффективного режима, энергозатрат и качественных показателей сушеных ягод. Эффективное время сублимации составило 4,5 часа. Внутри камеры при давлении (20 ± 5) Па и температуре (-42 ± 2) °С общее время замораживания и сублимации не превышало 5 часов, а общее время сушки составило 8 часов. Начальная масса клубники уменьшилась на 36%, смородины на 28% и малины на 27,4%. Сушку следует прекратить, когда температура в камере достигнет 40 °С.

Ключевые слова: сублиматор, автоматизация, алгоритм, датчик давления, датчик температуры, солнечный коллектор, генератор, панель управления, вакуумный насос, генератор.

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ОПРЕДЕЛЕНИЯ СКОРОСТИ ВОЗДУХА И РАСХОДА СУШИЛЬНОГО АГЕНТА НА ВХОДЕ И НА ВЫХОДЕ ГЕЛИОСУШИЛЬНОГО МОДУЛЯ

Аннотация

В статье представлены результаты исследований по процессу сушки яблок с использованием гелиосушильного модуля, который был установлен в полифункциональной теплице-сушилке на базе учебно-производственного хозяйства Казахского национального аграрного исследовательского университета.

Актуальность исследования. Организация процессов сушки при заготовке сушеных фруктов и овощей осуществляются путем использования традиционных видов энергии.