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Experimental Verification of the Operation of a Solar Dryer Such as an Advanced Greenhouse for Drying Grapes

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ABSTRACT: The high degree of solar radiation incident on the territory of the countries of Central Asia, especially Uzbekistan and Turkmenistan, makes it possible to maximize the use of solar installations. In this paper, the operating modes of a solar installation such as an advanced greenhouse are studied. The greenhouse type dryer is wrapped in polyethylene. The lower part of the dryer is thermally insulated and is located on a surface measuring 6.5x3m^2. To maintain humidity in the dryer, natural convection is used. This process is carried out using 2 changes:

- for access of air in addition installed two holes
- to exhaust the air, an additional hood was installed with a length of 9 m.

The dryer was built in Uzbekistan, the city of Bukhara. It twice dried grapes of 800 kg. The grapes were initially dried for 3 days at a humidity of 82%, then for 5 days in the sun. Thus dried grapes are completely protected from insects, pests, dust and rain. In addition, the dried grapes turned out to be clean and of high quality.

KEYWORDS*:* type greenhouse, insulation, range hood, advanced, solar dryer.

1. INTRODUCTION

Nowadays, in Central Asia, including Uzbekistan, dried fruits are mainly cooked outdoors. This method of drying fruits has its positive and negative sides. The disadvantages of this method are the following: a long drying process, an increase in atmospheric humidity, a partial loss of product on rainy days, adverse weather conditions, air pollution, dust, insects, etc. As a result, the amount of product is reduced and its cost is increased.

In the last 30 years, several types of solar dryers have been developed, but they are designed for 10-50 kg of fresh fruits and vegetables [1] and this does not satisfy the needs of the population. In addition, many devices used additional equipment (fans, solar panels, etc.) to ensure air flow [2,3,4], and also used additional flat collectors to warm the air inside the device [4]. This led to the fact that the cost of the drying device has increased dramatically. In addition, the creation of such a device requires additional knowledge and skills.

Given all of the above problems, our team of researchers has created a new greenhouse-type solar dryer. Knowing the geographical latitude of the territory, determining the dimensions of the bottom of the device, based on the utilization rate, using bolts and nuts, a lightweight, compact device was created in which parts can be assembled and disconnected.

To dry the grapes at the places of their ripening, a mobile sun-drying device was created. Such a device has passed the test on the heliopolygon Buch GU and the results are presented in this document.

II. METHODS

A. EXPERIMENT

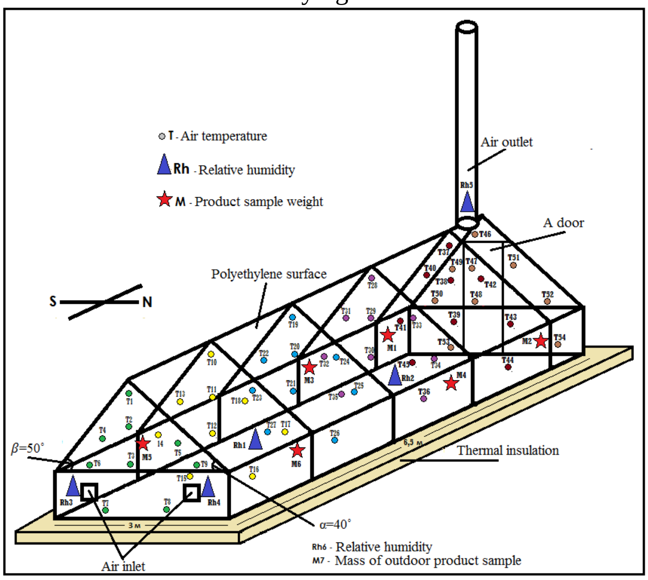
A greenhouse type dryer has been installed in the city of Bukhara, Uzbekistan. The width of the device is 3 m, the length is 6.5 m and the height is 2.2 m. In the dryer there are two openings with an area of 20x20 cm2 that serve as the occurrence of air flow (natural convection), in the gaps between the opposite walls, a chimney is installed in the upper part 9 m long. The drying device consists of sides, one of which is 400 from the horizon, and the other 500. The dryer is shown in Figure 1.

1-figure. Image of an advanced greenhouse dryer.

The sun's rays penetrate through the polyethylene with which the device is coated and warm the air inside the dryer, the products, as well as the insulated surface. Atmospheric air enters the inside of the dryer through openings that are located below on the side. Under the influence of sunlight, the air inside the dryer warms up and dries the products. On top of the opposite side of the air penetration holes, a chimney is installed through which warm, humid air comes out, and as a result, a process of natural convection occurs inside the dryer. A stream of warm air flowing through the hole takes moisture with it (in the process of natural convection) of the products being dried, and exits through the chimney. Under the influence of warm air, the humidity of the product evaporates and this speeds up the drying process.

B. EXPERIMENTAL PROCESS

In the present work, it was experimentally shown that in a greenhouse-type solar drying device, 800 kg of grapes can be dried (primary humidity 82%). In the September - October months of 2018, two experiments were conducted. The amount of energy from scorching sunlight was measured with a pyranometer (Kipp & Zone modeli CM 11, accuracy level 0,5%) mounted on the outside of the drying device.



2-figure. Schematic illustration of a grape dryer. The location of the measurement points inside the dryer: temperature (T), relative humidity inside the dryer (Rh) and product humidity (M).

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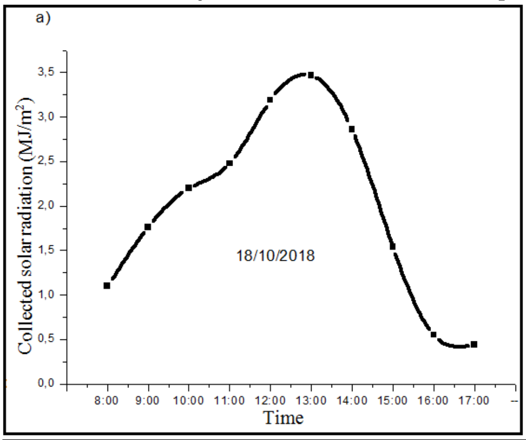
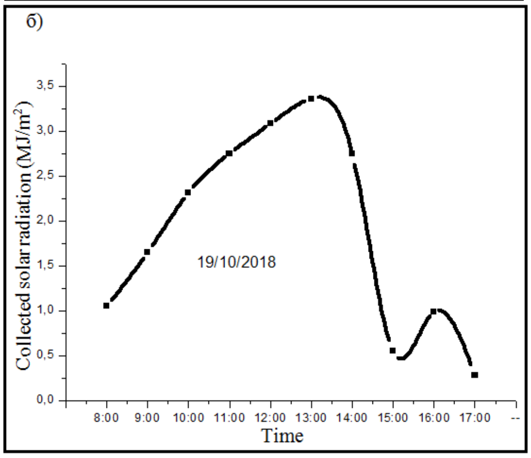
To measure the air temperature at different points of the dryer and the ambient temperature, electronic thermocouples (DIGITAL HYGRO-THERMOMETER, Measuring Temperature Rangei-SOtJ-yo'Cf-SS0 F - * - 158°F, Temperature Accuracy: ±1t (± 2°F)). The location of the installed thermocouples is shown in Figure 2. Anemometer (Airflow, model TA5, accuracy r 2%) was used to measure the air inlet and outlet speeds. From time to time, relative humidity inside the dryer and atmosphere was measured with a hygrometer (electronic (DIGITAL HYGRO-THERMOMETER, Measuring Humidity Range: 10% RH 99% RH, Humidity Accuracy: ± 5%, Humidity Display Resolution: 1% RH)). The readings of a pyranometer, hygrometer and thermocouples were recorded every hour.

In each experiment, 800 kg of grapes were placed inside the dryer. To place grapes on shelves inside the dryer, there is a special passage. The time for obtaining the results of the experiment lasted from 08:00 to 17:00. The drying process continued until the desired moisture level was obtained. Prototypes of products were placed in different places of the dryer and periodically, every two hours, weighed on an electronic balance (FEJ-1000B). The humidity of product samples located in the open air and inside the dryer was controlled and compared. During the drying process, the humidity of the product samples was measured for 24 hours and the following data were obtained: the evaporation of product moisture within 24 hours is: inside the dryer - 21%, and in the open air 12% (duration 24 hours, accuracy 0.5%).

III. RESULTS AND DISCUSSIONS

The experiment process for a greenhouse-type solar dryer was held in September-October 2018. During drying, solar radiation entering the dryer rises sharply from 8:00 to 13:00 (October 18 rises: from 1.1 MJ / m^2 to 3.47 MJ / m^2, October 19 from 1.05 MJ / m^2 to 3.36 MJ / m^2, on October 20 from 0.94 MJ / m^2 to 3.3 MJ / m^2), but after 13:00 it decreases significantly (on October 18 from 3.47 MJ / m^2 to 0.44 MJ / m^2, October 19 from 3.36 MJ / m^2 to 0.28 MJ / m^2, October 20 from 3.3 MJ / m^2 to 0.55 MJ / m^2) and changes under the influence of clouds. Figure 3- (a, b, c) shows the daily changes in solar radiation. Figure 4- (a, b, c), during the experiments, compares the air temperature readings (T2, T12, T21, T30, T39) in five places of the solar dryer with the ambient air temperature (during the day).





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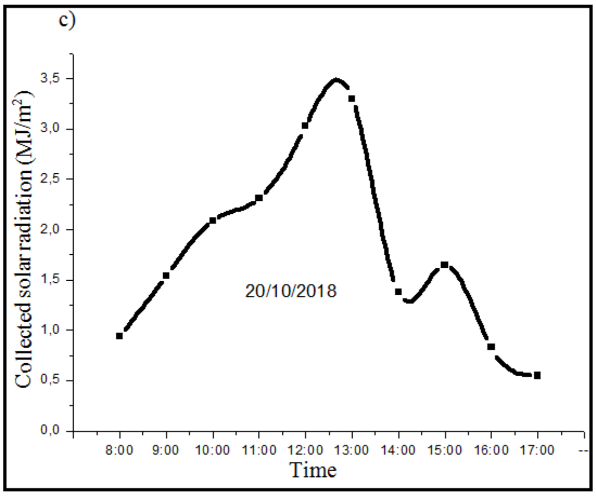
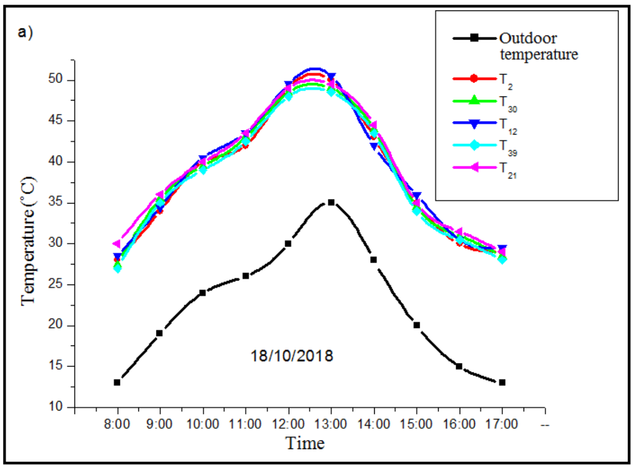


Figure 3- (a, b, c). The change in solar radiation over time during the drying of grapes.

It was possible to compare temperature changes at different points at different heights of the dryer. Compared in five places, the temperature does not differ much from the temperature at different heights. In addition, the air temperature at each point of the dryer is significantly different from the air temperature of the atmosphere (the air temperature at each point inside the dryer is higher than the atmospheric air temperature by an average of 15, 16°C). Figure 5- (a, b, c) compares the relative humidity of the ambient air and the air inside the dryer during the drying of grapes.

In the first half of the day, after a certain time, due to the temperature at different points of the dryer, the relative humidity decreases (October 18 from 48% to 13%, October 19 from 35% to 12%, October 20 from 41% to 15% decreases), and in the afternoon it is the other way around (October 18 from 13% to 38.6%, October 19 from 12% to 36%, October 20 from 15% to 39% rises). At different heights inside the dryer, relative humidity is not particularly different, but at the same time there is a significant difference between the relative humidity of the atmosphere and relative humidity at all points inside the dryer. Relative humidity below ambient temperature. Figure 5- (a, b, c) shows that the air leaving the dryer has a relative humidity that is much lower than the humidity of the ambient air (the humidity of the air leaving the dryer is on average 10.11% lower than the humidity of the ambient air). And this, creating a process of natural convection, increases the potential of the drying speed. The above results show that the dryer has a drying potential.

In fig. 6 (a, b, c) shows the change in moisture content in the dried product inside and outside the dryer. Before reaching 19% final moisture within three days, the humidity of the sample of dried products in the open air decreased by 47%. Dried products in different places of the greenhouse-type drying device hardly differ from each other. In addition, on this dryer, dried products are completely protected from insects, animals and adverse weather conditions. Figure 7- (a, b) shows the changes leading to the final moisture of raisins.



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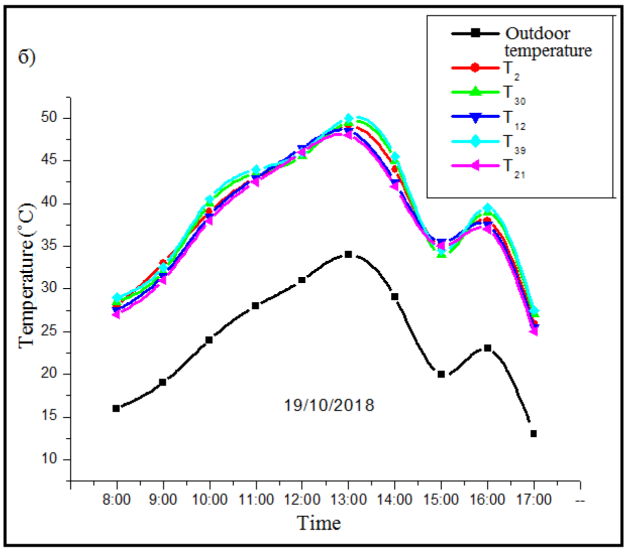


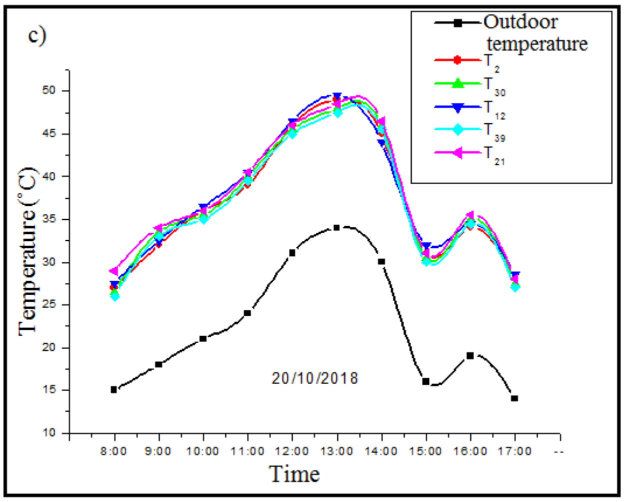
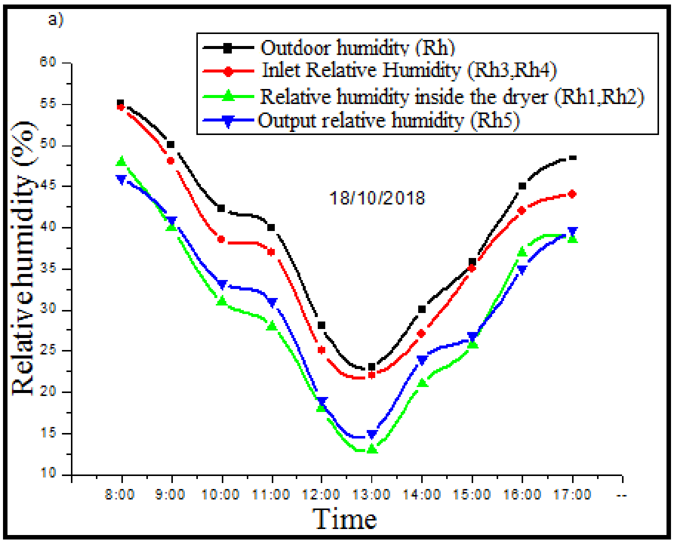


Figure 4- (a, b, c). Changes in temperature inside the dryer and the environment over time during the drying of grapes



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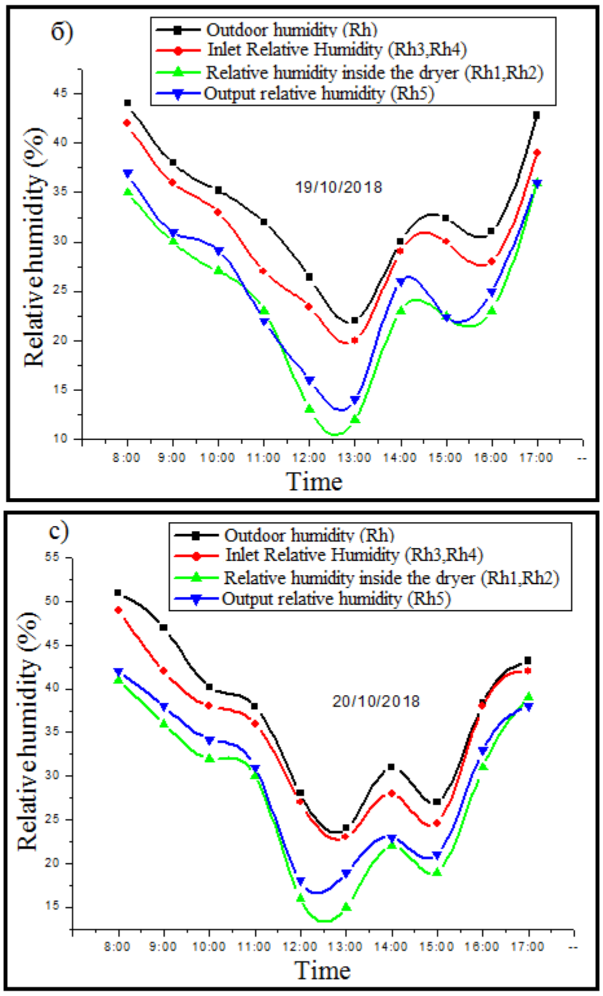
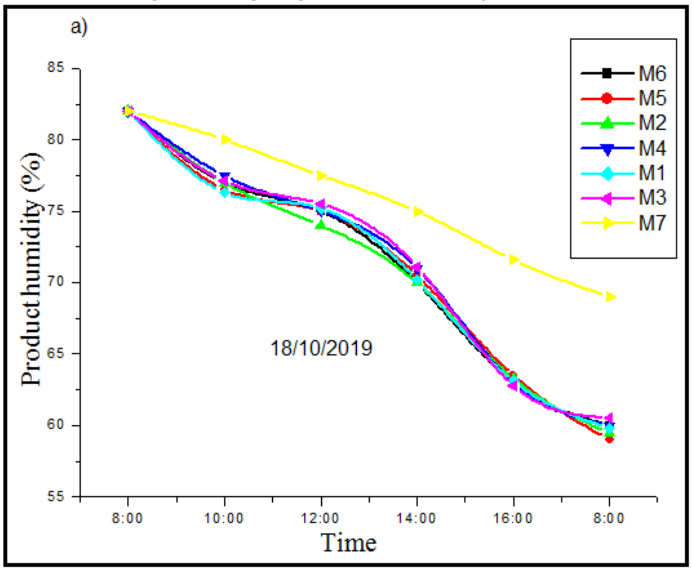


Figure 5- (a, b, c). Changes in relative humidity inside the dryer and atmospheric air; relative humidity of the incoming and outgoing air inside the dryer over time.



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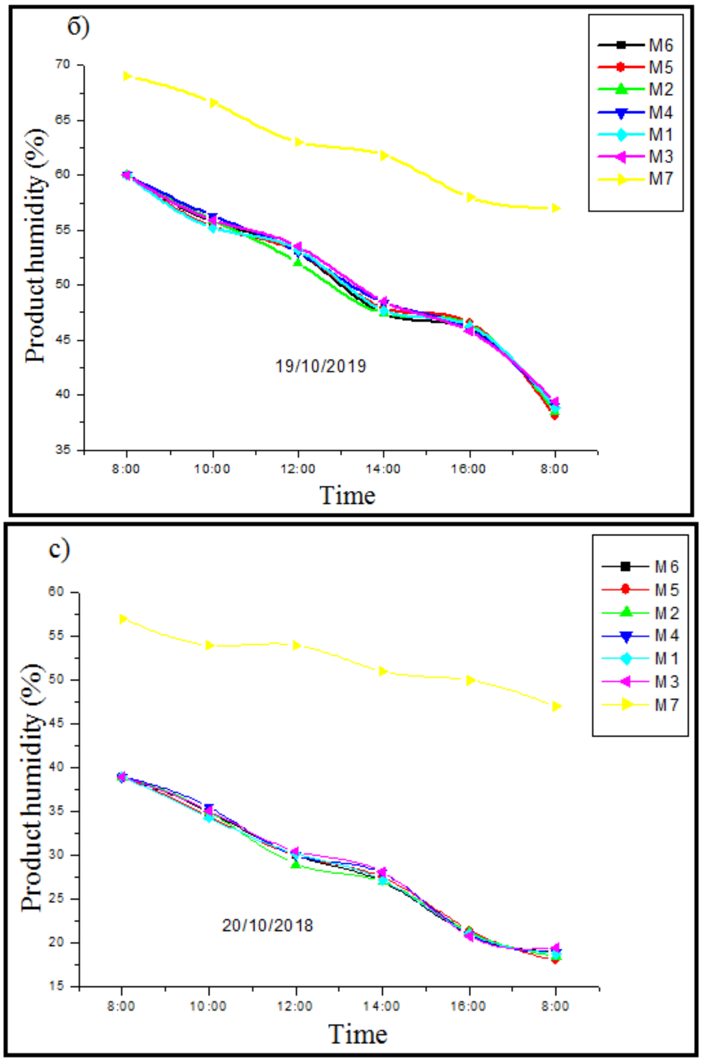
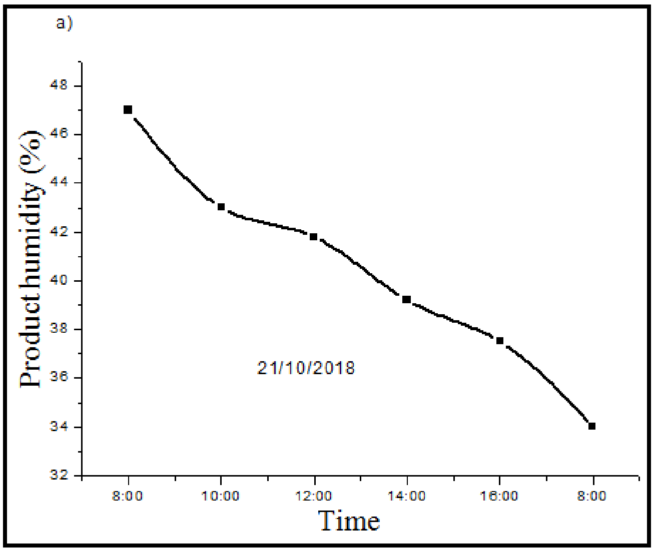


Figure 6- (a, b, c). Humidity of grapes in different places of the dryer and in the open air, comparison over time



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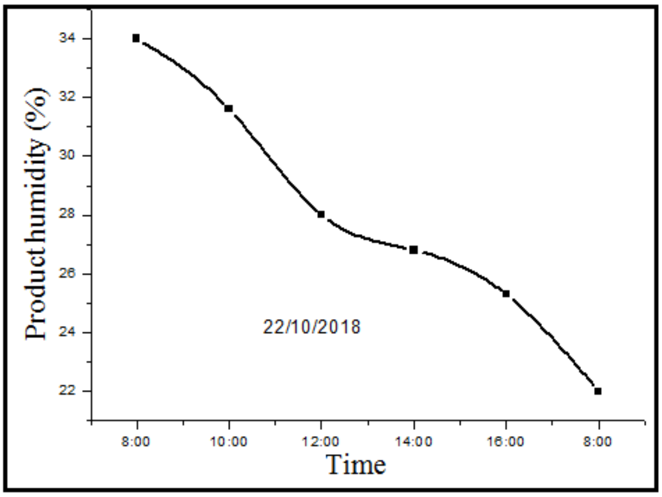

Figure 7- (a, b). Change over time in the humidity of grapes dried outdoors in the last two days of drying.

To assess the quality of the finished product, testing was carried out in an accredited experimental laboratory of the center of the Bukhara State Organization for Certification and Testing. Products tested in the Central Accredited Experimental Laboratory meet the requirements of 1.2.4 points of normative document GOST 6882-88. The obtained experimental results show that grapes dried on a solar dryer are no different from a quality product sold on the local market. If you evaluate from a financial point of view, to build and install a greenhouse-type solar dryer, you need an initial capital of $ 240 (1USD = 9,400 soum), the dryer capacity is 1,500 kg. According to the calculations, it was determined that the dryer can be used 20 times a year, after drying 1,500 kg of grapes. According to the same calculations, you can get 6000 kg of raisins per year. The calculations show that the sale of 3000 kg of dried raisins on a solar dryer, fully cover all costs made for the manufacture and installation of the device.

IV. CONCLUSION

To study the operating mode of the advanced greenhouse-type solar dryer, grapes in the amount of 800 kg were twice dried in the heliopolygon of BukhSU. It was found that when drying grapes in a greenhouse-type solar dryer, the product wins in drying time (48 hours) than when drying in the open air. In addition, the products dried in our dryer are of the best quality and color. The duration of the greenhouse-type solar dryer is 2 years. More than ten pieces of such a device are currently used in small-scale farms. And already received products, high-quality raisins.

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