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*RESEARCH ARTICLE*

# VALORIZATION OF ONION AND TOMATO THROUGH SOLAR DRYING: CASE OF THE SHELL SOLAR DRYER

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## Abstract

One of the most widely grown vegetable crops in Burkina Faso is onion and tomato. Solar drying is crucial for the conservation of these products. One of the most accessible solar dryers is the shell solar dryer, which allows these products to be dried hygienically. We were able to obtain some results from the experiment carried out over three typical days with a solar dryer which shelled 1116 g of onion and 695 g of tomato cut and distributed on the three racks of the dryer. We observed a total water loss of 456 g for the onion and 257 g for the tomato from the first to the third day of the experiment. The shell solar dryer has an efficiency of 29.88% with an inlet temperature of 33°C, an outlet temperature of 76°C and an air mass flow rate of 0.004 kg/s. The average solar irradiation is 579 W/m $^2$.



## Introduction:-

The onion, native to Central Asia, is cultivated as a vegetable plant for its bulbs and leaves **[1].** It constitutes a basic ingredient for culinary preparations in all regions of the world **[2].** The onion is a vegetable that has nutritional, nutritional and therapeutic benefits **[3].** It is one of the most consumed vegetables in the world. Nutritionally, onion is considering as energetic, protective and supportive food, because it contains vitamins (B vitamins, vitamin C, provitamin A), minerals (potassium, sodium, zinc, iron, phosphorus, selenium, magnesium, manganese, calcium, etc.), lipids, proteins, carbohydrates, essential oils, organic acids, fibers **[4]**. Annual global production was estimated at over 75,000,000 tons in 2009 **[5]** . The major producers of bulb onions in West Africa are Niger, Nigeria, Senegal and Burkina Faso **[6]** .

The tomato is native to the coastal regions of northwest South America (Colombia, Ecuador, Peru, northern Chile). The latter is currently widespread in all tropical regions of the globe, but these are recent introductions. It was introduced to Europe at the beginning of the 16th century by the Spaniards, first in Spain, then in Italy through Naples. The tomato is a vegetable rich in water, it also contains some organic elements, minerals and vitamins **[7]** .

In Burkina Faso, the total production of market gardening was estimated at 747,488 tons in 2008. The total production of onions was 242,258 tons, or 32.4% of total market gardening production **[8].** Such a proportion gives this speculation first place among market garden products.However, production techniques still remain traditional

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and the areas exploited vary between 0.05 and 0.25 ha for 90% of producers. Yields vary from one area to another, but there is a clear increase from 15 T/ha in 2005 to 21 T/ha in 2008, an increase of around 40% **[9]** . This considerable production is poorly distributed over time. Production is concentrated in a short period of the year (the cold dry season), with the rest of the year being the dead period from a production point of view. Also, from March until June, the local market is in surplus, while from August until September, December, we only find onions of Dutch origin on the market.

The tomato, on the other hand, also occupies an important place in market gardening production. The tomato sector in Burkina Faso stands out today with production reaching the mark of 300,000 tons per year **[10].** According to the general agricultural census which took place in 2011, the tomato ranks second among market gardening crops in Burkina Faso in terms of production and area sown, after the bulb onion. With an increase in the population of around 3.1%, the demand for tomatoes from the Burkinabe domestic market continues to increase (FAO, 2007). Likewise, the demand from sub-regional markets for market garden products is increasingly growing **[11].**

Tomatoes contribute to improving the diet and nutrition of the population (2% of production is self-consumed). It also contributes to job creation, in fact, there are 177,500 producers for all market garden crops, including tomatoes **[12].**

In Burkina Faso, the seasonal nature of onion and tomato production requires their conservation in order to make them available all year round. Note that the thermal analysis of a photovoltaic cold room with a peak power of 3 kW shows a real possibility of conservation of 15% for all varieties of mango, one of the most produced commodities in Burkina Faso **[13].** Solar drying is one of the means used for the preservation of food products. However, the drying practice commonly used by producers and family units is traditional. When drying by this method, losses are considerable from a qualitative and quantitative point of view. This is because the product is usually contaminated by dust, weather and animals, especially insects. In recent years, several models of solar dryers have been developed and produced for drying fresh products. The shell-shaped solar dryer is one of the models developed which is particularly hygienic and ideal for use with the family. The results of an experimental study on the solar drying of agri-food products (onions and tomatoes) are presented in this article. An indirect natural convection dryer, also known as a shell dryer, was used to carry out the drying procedure. This type of drying is practical, inexpensive and suitable for drying food products. The choice of onion and tomato is justified because of their economic, health and social benefits. The experimental determination of their drying kinetics is our objective.

## Materials and Methods:-

**1- shell dryer**

The collector of the shell solar dryer transforms solar radiation into heat. Air enters the collector from below, heats up and increases its temperature. The product is then dried by this air and exits through the chimney. It includes: A box is a closed enclosure made up of three parts: a lower cone-shaped part, a belt perforated by three rectangular air inlets covered with mesh, and an upper part also cone-shaped. The legs or supports needed to keep the crate upright and off the ground. Racks placed in the crate. The products intended to dry are placed on these racks. A chimney intends to evacuate humidity; The whole thing is painted matte black in order to capture the maximum amount of sunlight.

**2-Preparation of the product**

The onion is peeled, washed then cut into thin slices (rounds) without the hard parts. It is then spread on the racks without being superimposed, the mass of the product to be dried is 1116g distributed between the racks for the entire experiment.

Sort and choose tomatoes that are ripe and firm and have a beautiful color, then wash them to remove impurities; - Cut the product into 4 slices for small tomatoes and 8 for large ones or then remove the seeds; The cut slices are placed on the racks, the initial mass of the product is 695g;

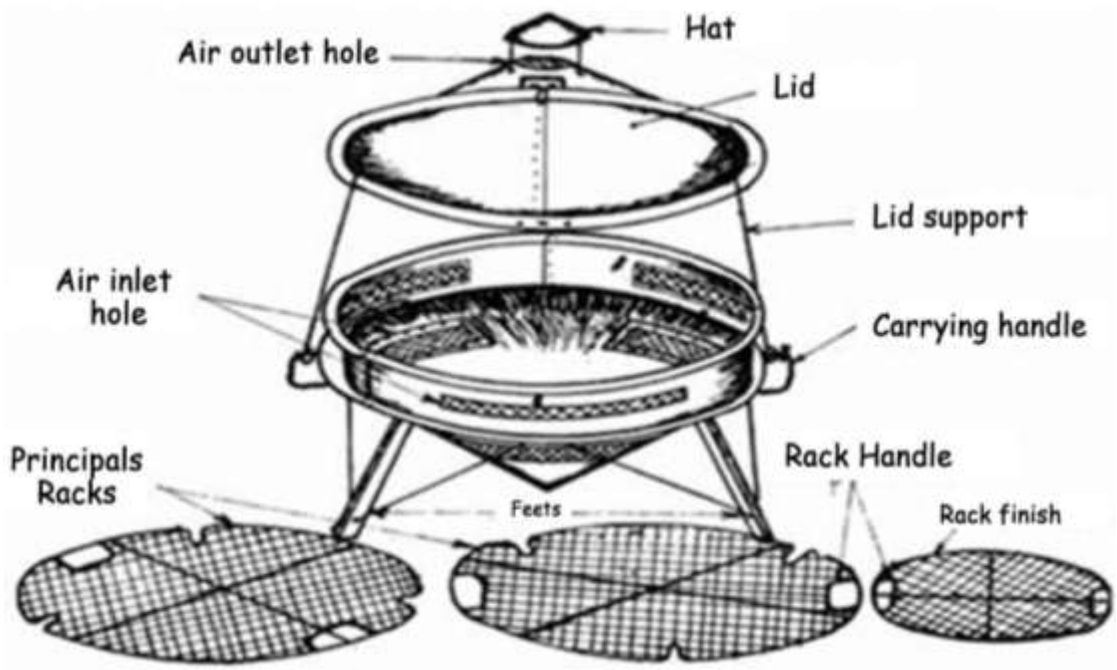



**Figure 1:-** Shellfish drying with three racks.

**Figure 2:-** Tomatoes spread out on the racksfigure.

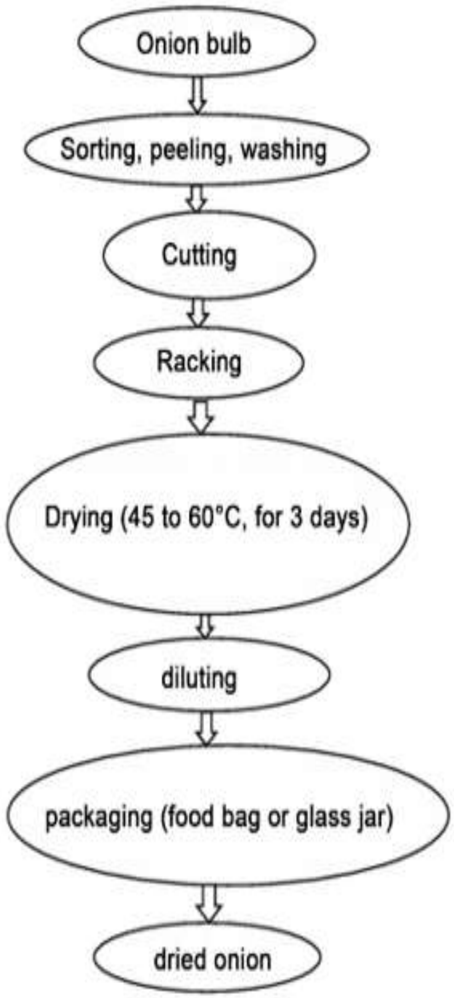
**Figure 3**:- Onions spread out on the racks.

**3-Measuring equipment**

During these three days of drying, we weighed the tomatoes and onion every 30 minutes using a Severin digital scale to monitor the change in mass during storage. During the days of the experiment, a solarimeter is placed on a horizontal plane on the experimental site to monitor the daily radiation. Every ten minutes, a hygrometer is used to measure the relative humidity of the ambient air. A Velleman DVM171THT humidity meter is used every 5 minutes to measure the humidity of the ambient air.

**4-Production diagram of dried onion and dried tomato**

The onion is dried during the first week of August (4 to 6) and the second week of September (September 10 to 12) at IRSAT in Ouagadougou, Burkina Faso. Figures 8 and 9 show how the onions and tomatoes were prepared before being dried in the shell solar dryer. Our research focused on constant mass measurements.



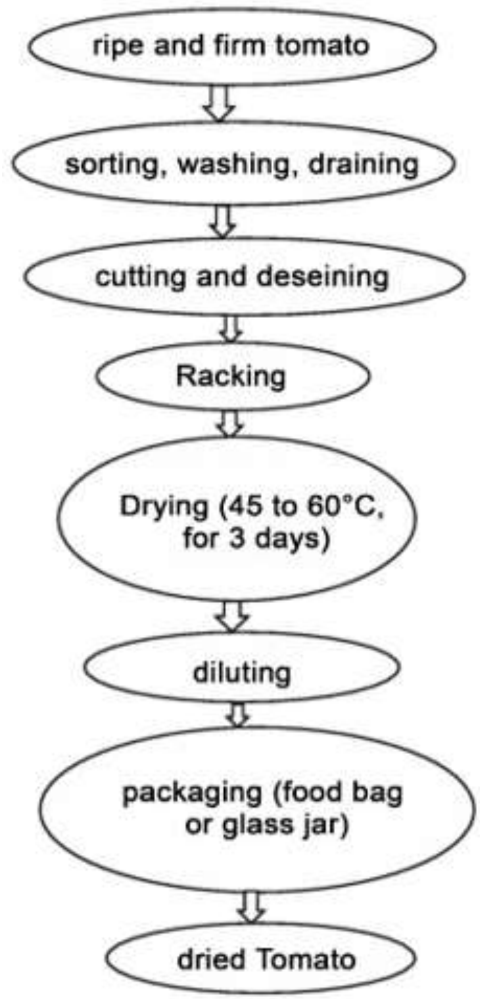




**Figure 4:-** Onion drying diagram.**Figure 5:-** Tomato drying diagram.

## Results and Discussions:-

**1 -Evolution of temperature and solar radiation**

For the three days of the experiment, the curves in Figure 10 show the evolution of solar radiation and temperature as a function of time. The third day of the experiment had the average maximum radiation of 634.4 W/m $^2$ and the maximum ambient temperature of 37.20°C. The second day of the experiment recorded the lowest radiation and lowest temperature.

The overall shape of the solar radiation curve is Gaussian. However, there are sudden variations in the values caused by the passage of clouds, which causes drops on these curves. The radiation values from the second day show that the recorded values are not very high. This is due to the fact that August was a rainy period in Burkina Faso.

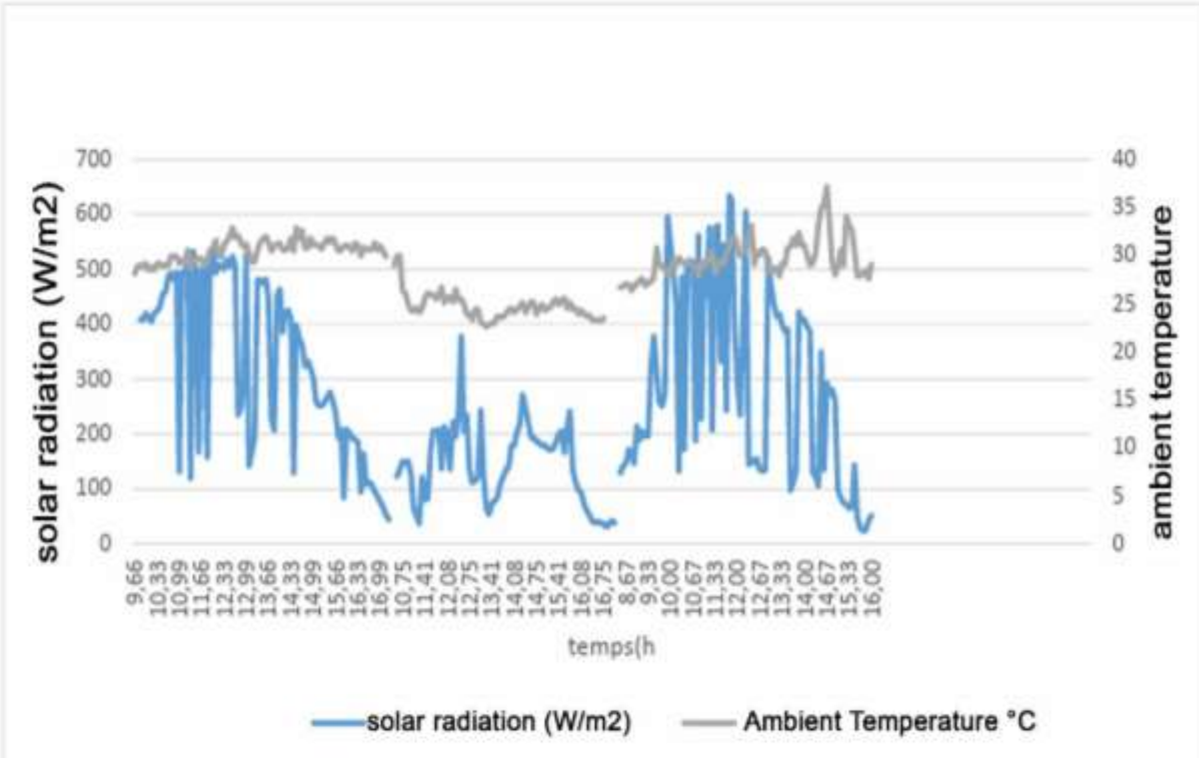



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**Figure 6:-** Evolution of solar radiation and ambient temperature as a function of time.

**2-Evolution of the mass of the product during the drying of the onion**

The onion lasted three days (August 4-6). Two racks were used to arrange the onions.

As shown in Figure 11, on the first day of drying the first rack, the mass decreased from 562 g to 198 g, resulting in a water loss of 364 g. On the second and third days, the decrease is less significant. The mass decreases from 175 g to 116 g and from 115 g to 82 g, respectively, with a water loss of 59 g and 33 g. This means that the curve of the evolution of the mass is almost linear on the third day.

The evolution of the mass on the second rack is almost identical to that of the first rack. The difference observed is extremely minimal. The low mass of the products and the short distance between the two racks contribute to this.

The curves in Figure 12 show the amount of water lost by the onion on the two racks during the drying process. As expected from the results in Figure 11, the amount of water lost on the two racks is practically the same during the drying process.

The following expression was used to calculate the initial water content from the dry mass:

$$X_0 = \frac{m_0}{m_s} - 1 \qquad (1)$$

It is worth 6.11kg water/kg.$m_s$ or 86%.

The water content at the moment was determined from the initial water content by the following relationship:

$$X = \frac{m(X_0 + 1)}{m_0} - 1 \qquad (2)$$

The curve in Figure 13 shows the evolution of the quantity of water in the onion, with a linear decrease. This result is similar to the drying of food products. The first day of drying is more accelerated than the last two days according to the curve. The evacuation of surface water at the start of drying explains this. The drainage of water into the depths of the onion is known as slowing down.

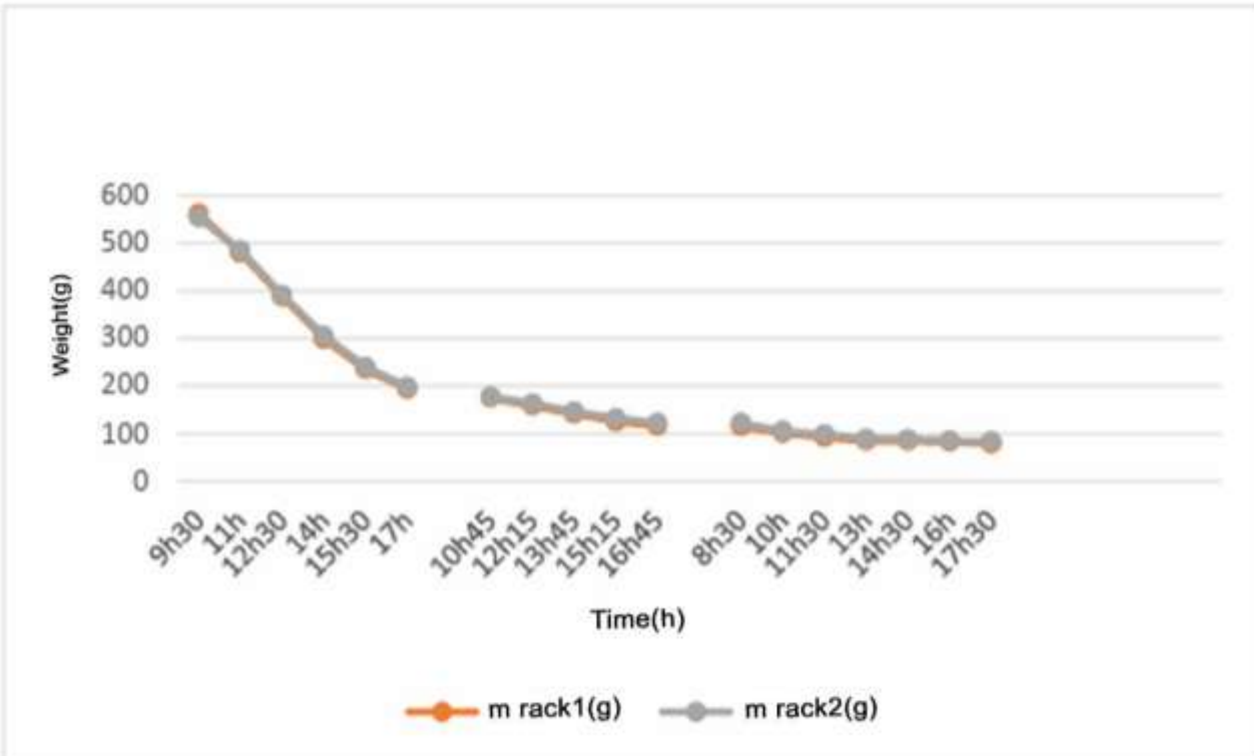


**Figure 7:-** Temporal evolution of the mass of onions per rack over the three days.

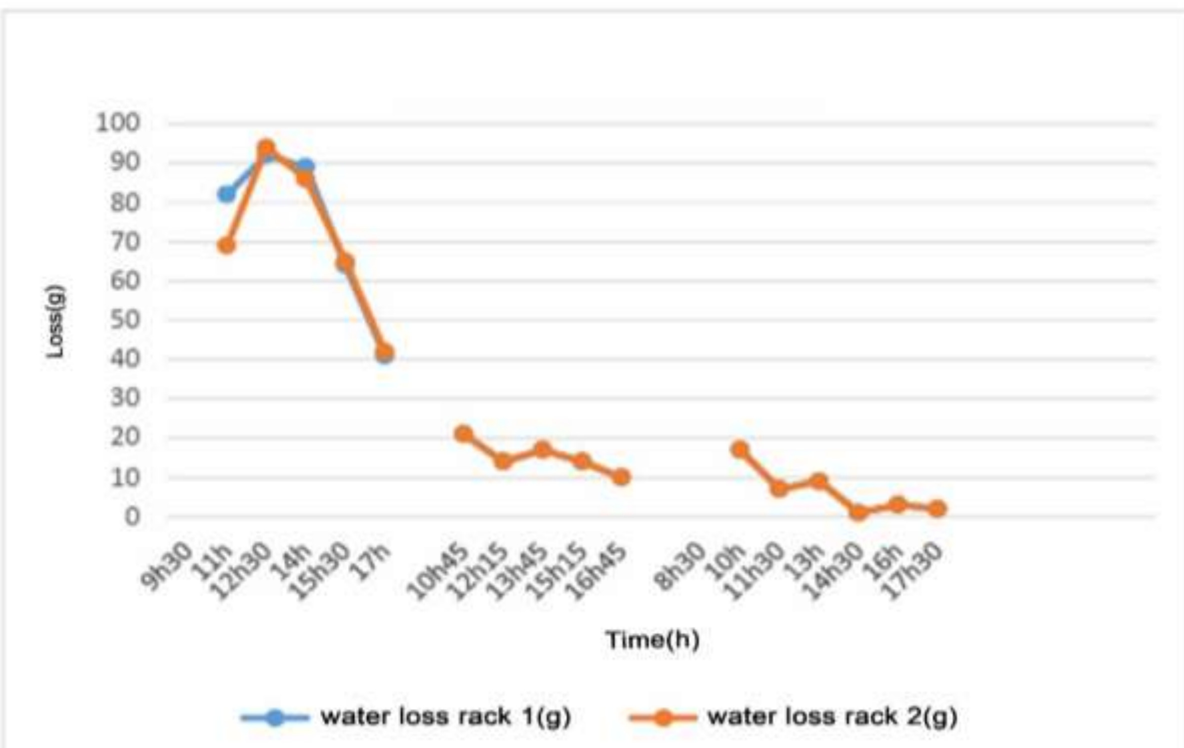


**Figure 8:-** Temporal evolution of water loss by racks over the three days.

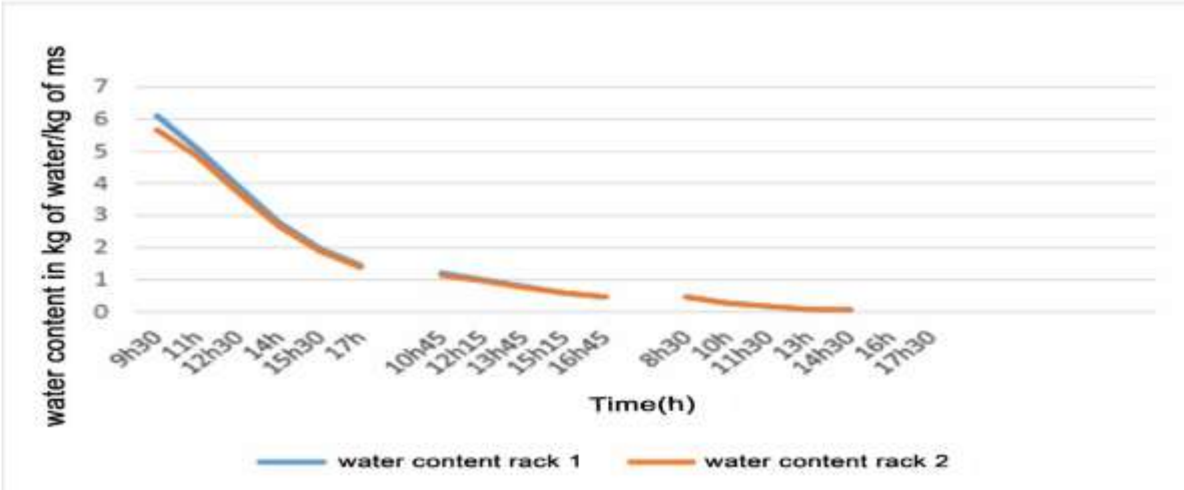


**Figure 9:-** Temporal evolution of the water content per rack over the three days.

Figure 14 shows the evolution of radiation and relative humidity as a function of time during the three days of drying. We note that strong solar radiation records low relative air humidity and vice versa. This analysis demonstrates that solar radiation and temperature are linked to the value of relative humidity. The relative humidity values of the air vary from 40 to 80% which demonstrates its humid character or not.

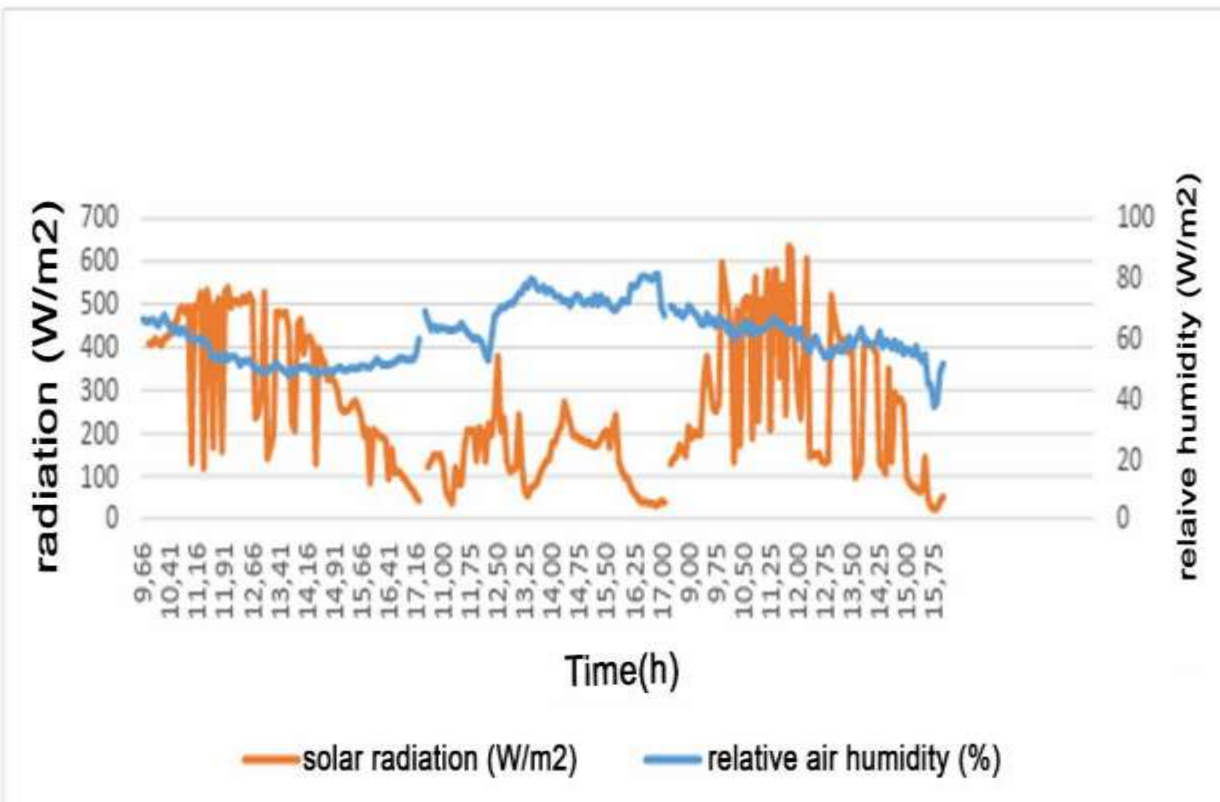


**Figure 10:-** Temporal evolution of radiation and relative humidity of the air over the three days.

The evolution of temperatures as a function of time is illustrated by the curves in Figure 15 below, which show the ambient temperature, the temperature of the two racks and the temperature of the hot air at the outlet of the dryer. The air temperature at the outlet of the drying box is the highest, while the ambient temperature is the lowest. The fact that the air transfers sensible heat to the onion during its passage from the first to the second rack justifies the drop in the air temperature on the two racks. Despite the bad weather, the temperatures recorded in the drying room reached a temperature of 60°C.

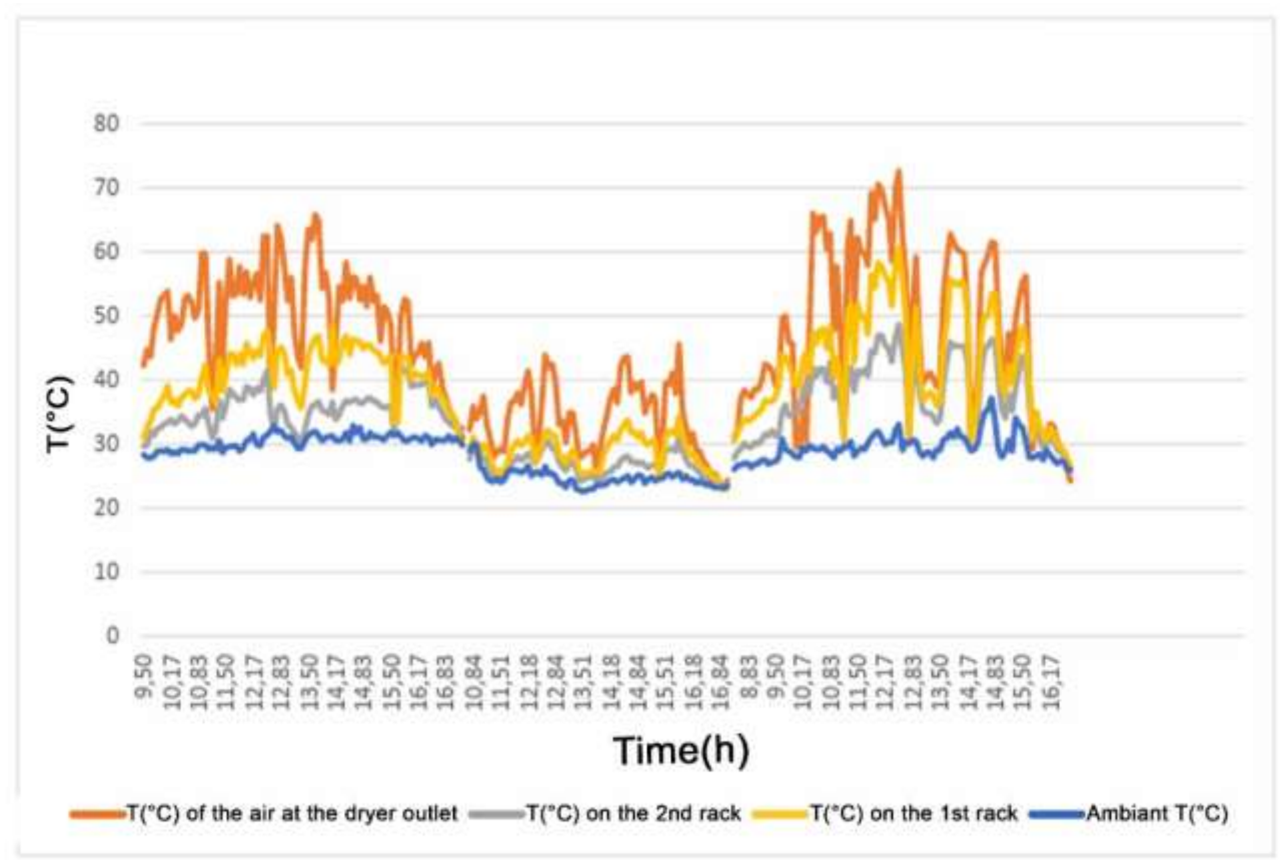


**Figure 11:-** Temporal evolution of temperature over the three days.

**3- Evolution of the mass of the product during the drying of the tomato**

The tomato was dried for three days (September 10–12). The curves in Figure 16 show the evolution of drying on the two racks over these three days. On the first day, the mass fluctuates slightly, from 370 g to 278 g, resulting in a water loss of 92 g. The day's bad weather (rain) forced the experiment to stop at 2 p.m. On the second day, she lost 123 g of water, going from 247 g to 124 g. The better drying of the second day compared to the first day is justified by the better weather of the second day and the bad weather of the first day. The third day the mass goes from 100 g to 58 g, i.e. a water loss of 42 g, slowing down compared to the second day is due to the fact that the evaporated water is now the water found in the depths of the tomato slices. The observations made above for the first rack are identical to those for the second. Unlike the first experience with the onion, drying is carried out better on the second rack than on the first.

The curves in Figure 17 show the variation in the water content of the tomato as a function of time. We can notice that it decreases over time, which shows that there is continuous evaporation of water as the temperature increases over these three days.

The variation of the relative humidity of the air as a function of time for the three days of the experiment is observed by the curves in Figure 18. We note that the relative humidity of the air varies on average between 60% at 80% except for the two peaks observed on the second day. This shows that the drying air used was very humid, probably due to the cool period.

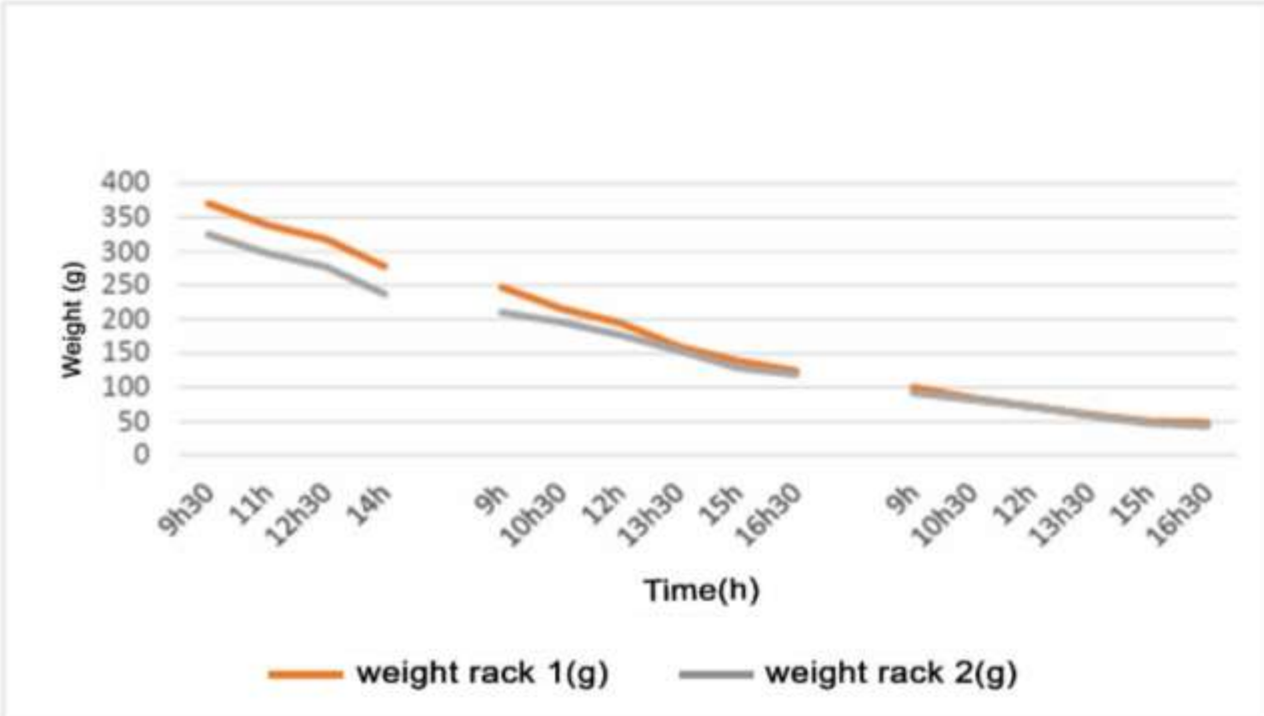


**Figure 12:-** Temporal evolution of the mass per rack over the three days.

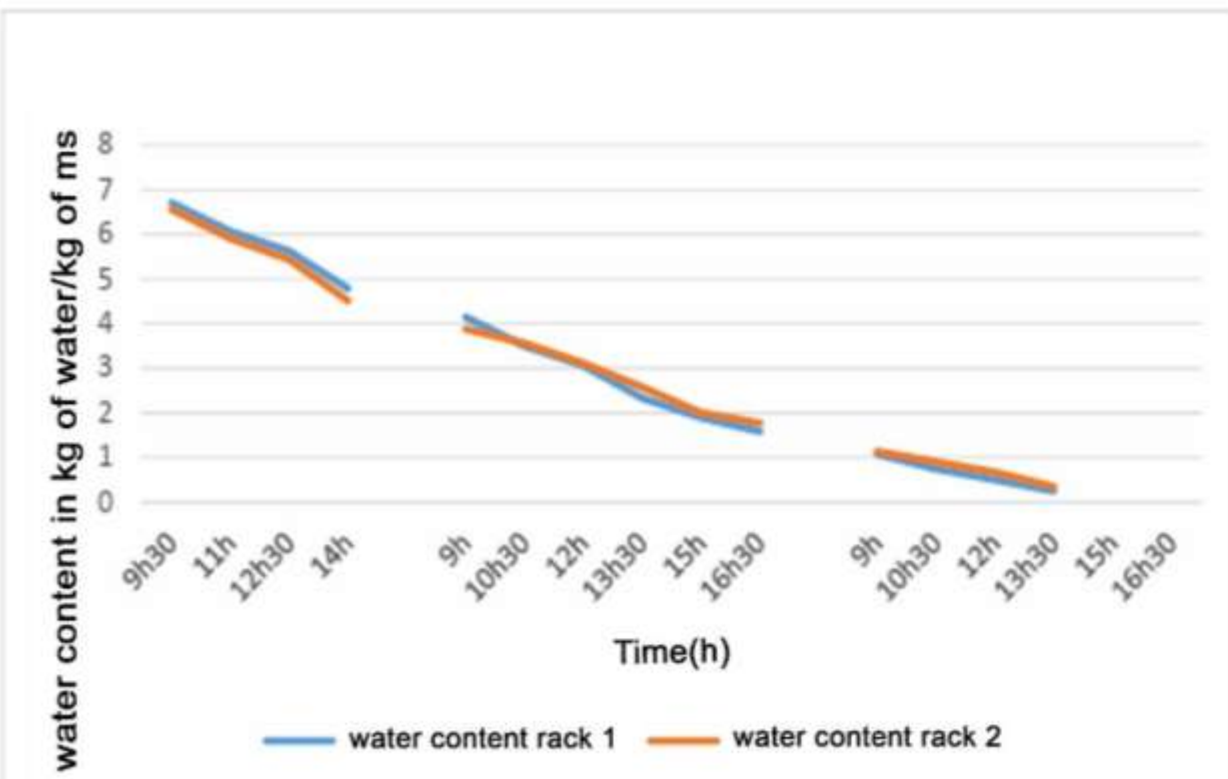


**Figure 13:-** Temporal evolution of the water content per rack over the three days.

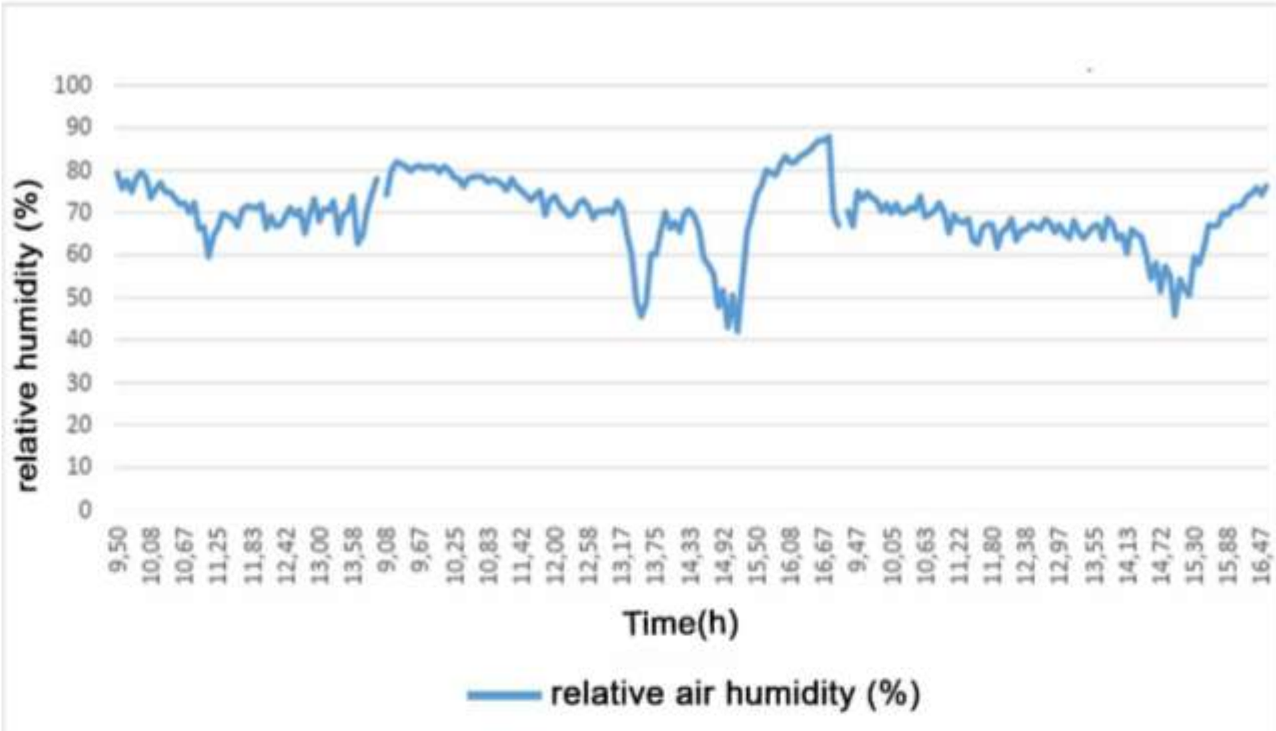


**Figure 14:-** Temporal evolution of relative air humidity over the three days.

4- **Dryer performance**

The yield reflects the performance of the dryer. It is calculated using the following expression:

$$\eta = \frac{\dot{m} c_p (T_f - T_e)}{I_C} \qquad (3)$$

The mass flow rate of the air is $\dot{m}$ = 0.004 kg/s m2 with an inlet temperature of Te = 33 °C and an outlet temperature of $T_f$ = 76 °C. Due to the specific capacity of ambient air of 1.006 kj/kg/°C, the solar irradiation is 579 W/m $^2$. A yield of 29.88% was obtained.

**5-result of drying**

The dried onions and tomatoes obtained are packaged in a bag before being stored as shown in Figure 19.

Dried onion dried tomato

**Figure 15:-** Packaging of onion and tomato.

## Conclusion:-

We can conclude that our objectives are achieved because the study of the kinetics of solar drying of onion and tomato shows only the slowing down phase, the absence of the product heating phase and the phase at constant speed. Only the diffusion mechanism is responsible for the drying of the tomato and the onion, according to the drying kinetics at a decreasing rate. Drying time also depends on several factors, including the mass of the product.

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