

# Drying Kinetic Cassava with Solar Dryer Forced Convection Indirect

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## Abstract

An experimental convection drying cassava forced study was conducted using a solar dryer with forced convection, an oven and a precision balance. This study identified the cassava drying kinetics at different racks of drying. These kinetics were obtained by comparing first on each rack and between racks. Threads rotate about the influence of the distribution of the products on the trays, then the position of the trays and finally to the hot air supply of the drying cubicle. The conclusions obtained require us to take account of these findings in the design of indirect solar dryer.

**Keywords:** indirect solar dryer, forced convection, drying kinetics, dried cassava, evolution of the water content.

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## NOMENCLATURE

Mh: instantaneous wet mass of the control products in kg

Ms: dry or anhydrous mass of control products in kg

X: Instantaneous water content of control products in %

WhA1: Kinetics of drying of the control product on the first rack and placed just at the entrance of the cabin.

WhA2: Kinetics of drying of the control product on the first rack and placed at the end of the rack according to the direction of air flow.

WhB1: Kinetics of drying of the control product on the second rack and placed just at the entrance of the cabin.

WhB2: Kinetics of drying of the control product on the second rack and placed at the end of the rack according to the direction of the air flow.

WhC1: Kinetics of drying of the control product on the third rack and placed just at the entrance of the cabin

WhC2: Kinetics of drying of the control product on the third rack and placed at the end of the rack according to the direction of the air flow.

WhD1: Kinetics of drying of the control product on the fourth rack and placed just at the entrance of the cabin

WhD2: Kinetics of drying of the control product on the fourth rack and placed at the end of the rack according to the direction of the air flow

WhE1: Kinetics of drying of the control product on the fifth rack and placed just at the entrance of the cabin

WhE2: Kinetics of drying of the control product on the fifth rack and placed at the end of the rack according to the direction of the air flow

## INTRODUCTION

Drying is an important operation in the agricultural and industrial fields. It consists in the complete elimination or partial water of a product [1]. The drying results in better retention or flour processing example of certain foodstuffs. Solar energy is the sustainable solution in countries where no conventional energy resources such as Senegal. When the solar drying of low energy food products, solar rays are used as a heating medium.

Tests indirect solar dryer, forced air, for the determination of curves representing the cassava drying kinetics, has been made Center for Studies and Research in Renewable Energy of Senegal. The dryer uses thermal energy from the sun by conversion into heat rays with an air sensor designed for this purpose and photovoltaic solar energy for the operation in forced convection. Its design and implementation were made after sizing up to the choice of the local availability of building materials [2, 3].

Some work has been carried out on the drying of cassava, namely the authors Ahouannou *et al.*, on the identification of the values of the characteristic parameters of drying by the method of the Characteristic Drying curve (CCS) in the year 2000.

The experimental study of this dryer is based on the drying of cassava tubers to determine the drying kinetics at different screens, specifically the influence of their position on the drying rate.

The main objective of this study was the determination of the efficiency of the indirect solar dryer forced convection by determining cassava drying kinetics. These drying curves are obtained by plotting the evolution of the water content of the product over time for different screens.

## MATERIALS AND METHOD

Recall that the dryer used is an indirect solar dryer. The product is dried away from sunlight for better conservation of the intrinsic properties of the dried product. During drying, several phenomena occur, the most significant are the transfer of water and heat, solute transfer and aromas, the deformation of the product, etc [4]. The principle of the dryer is simple and involves heating the ambient air by passing through the hot air tunnel production. Using fans, drying gas is conveyed in the drying chamber where the products are exposed to dry and was then removed from the dryer after moisture loading.

### Description Solar Dryer



Fig-0: Side sight of the solar drier

This dryer has four centrifugal fans which can operate simultaneously, individually or in part. These fans operate DC voltage and have a de12V. With the help of a 20Wc of photovoltaic solar panel, we have the necessary power source to operate all at the same time fans. Three are located at the entrance of the sensor and allow air to properly circulate to arrive in the drying chamber. After several tests, we found that the hot air feed rate was not uniform, which is why the fourth fan is positioned in front of the diffuser channel to enable better distribution of hot air level of all the hurdles and at the same time.

### Framing the Dryer Drying Cabin

It has a cubic shape and has five drying racks arranged as a shelf. The side walls are thermally insulated with glass wool thick five cm, thus allowing better conservation of heat in the drying chamber. The trays are spaced eight cm for better circulation of hot air. The drying gas enters the booth through the side openings in each rack out on other located opposite.

### Insulation Dryer

All parts except the moist air outlet openings are thermally insulated with glass wool thick eight cm. For better absorption of sunlight, the dryer is painted matte black.

### Solar Air

The sensor is first plane and air. It is mainly composed of three parts: the upper surface (surface of transparent clear glass of 6 mm) for trapping in the solar rays, the location of fans located upstream of the sensor and the isolated absorber downwardly always with glass wool. It is attached to the drying cubicle and supplies hot air. Fans can regulate the flow and the required temperature at the right drying. Depending on the sunshine, the temperature may reach a maximum value of about 75° C.

### Drying Racks

To prevent oxidation and contamination phenomena, the trays are made with a profiled frame and a mesh aluminum square mesh. Aluminum also allows better transmission by conduction the heat received.

### Experimental method

The materials used for the determination of drying kinetics are mainly:

- A precision 0.01g precision balance: to weigh samples of the products until constant masses;
- A ventilated oven and regulated in temperature and relative humidity. It can determine the masses of different samples. For this, a more accurate balance (0.0001 g) with a dryer is used.

### Obtaining drying curves

Drying curves are obtained by hot-air training through perforated screens which are spread the products to be dried in a thin layer (1-3 cm).

Mean drying curves, the water content of the curves representing the variations as a function of time  $t$ , or those providing the drying rate as a function of time  $t$  or the water content. There are several characteristic curves showing the changes:

The water content as a function of time:

$$X = f(t) \dots\dots\dots (1)$$

The drying rate versus time:

$$\frac{dX}{dt} = f(t) \dots\dots\dots (2)$$

The drying rate depending on the water content:

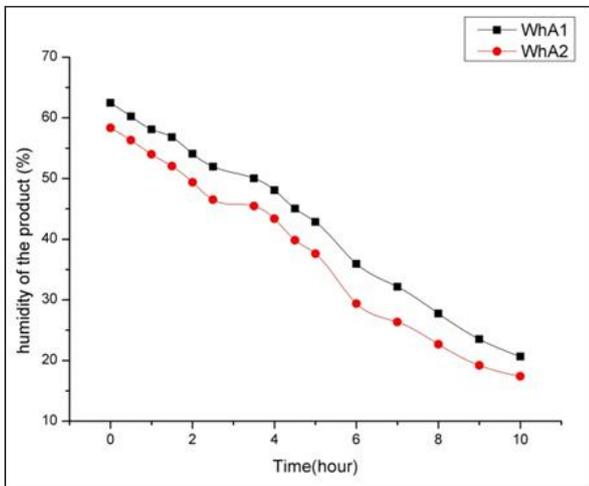
$$\frac{dX}{dt} = f(X) \dots\dots\dots (3)$$

The curves obtained experimentally are obtained by following the evolution of the product wet mass  $M_h$  being dried by successive weighings until the final water content  $X_{fin}$ .

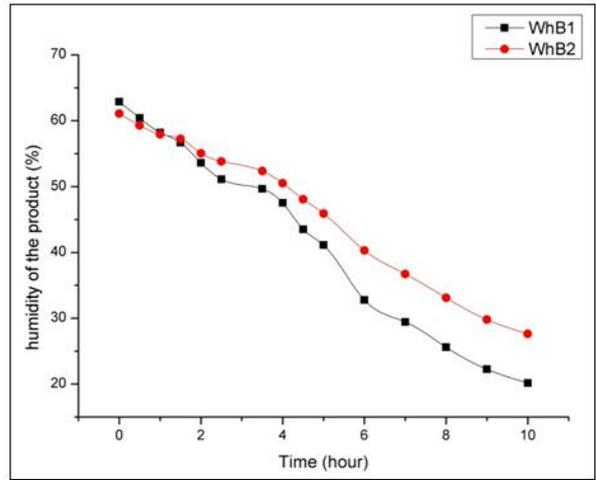
After drying, the sample used is placed in the oven heated to  $105^\circ \text{C}$ . After 4h, after several successive weighings, the sample mass no longer changes, it corresponds to the dry mass ( $M_s$ ) of the sample. From this value, the initial water content of the sample is calculated by the following equation:

$$X(t) = \frac{M_h - M_s}{M_s} \dots\dots\dots (4)$$

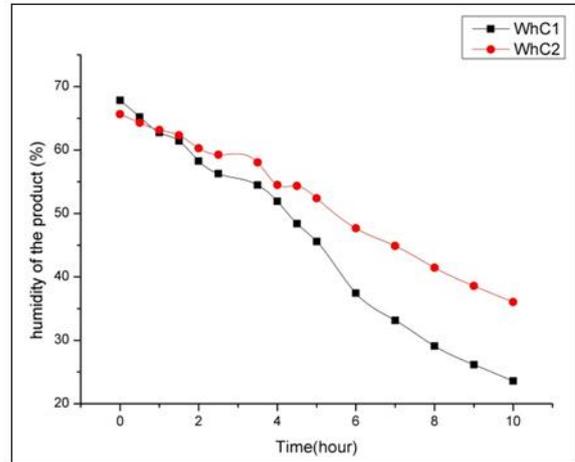
**RESULTS AND DISCUSSION**



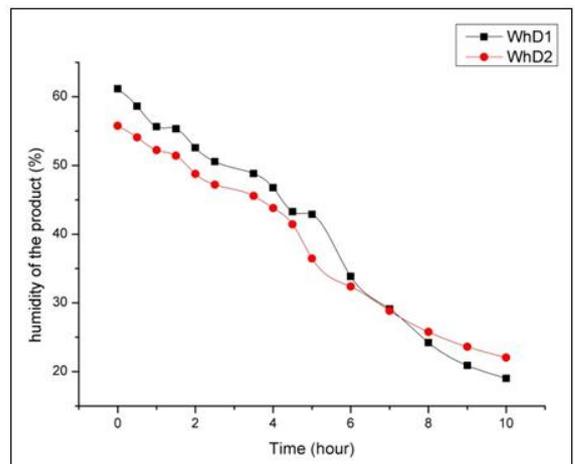
**Fig-1: Comparison of the drying kinetics of products positioned with space differences at the level of the first drying rack**



**Fig-2: Comparison of the drying kinetics of the products positioned with space differences at the level of the second drying rack**



**Fig-3: Comparison of the drying kinetics of the products positioned with space differences at the level of the third drying rack**



**Fig-4: Influence of the rack position on the drying kinetics**

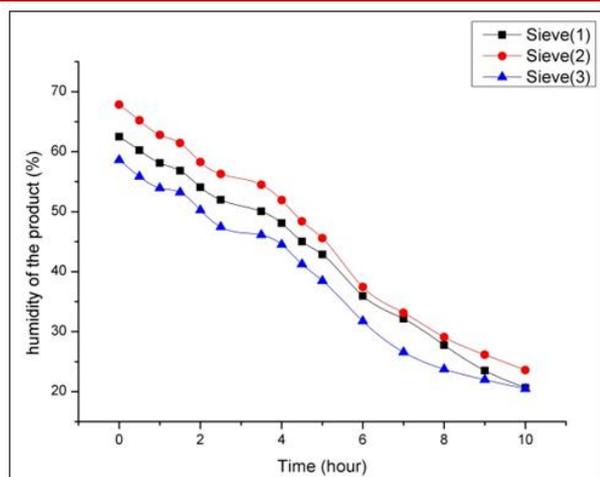


Fig-5: Influence of the nature of the product water on the drying kinetics

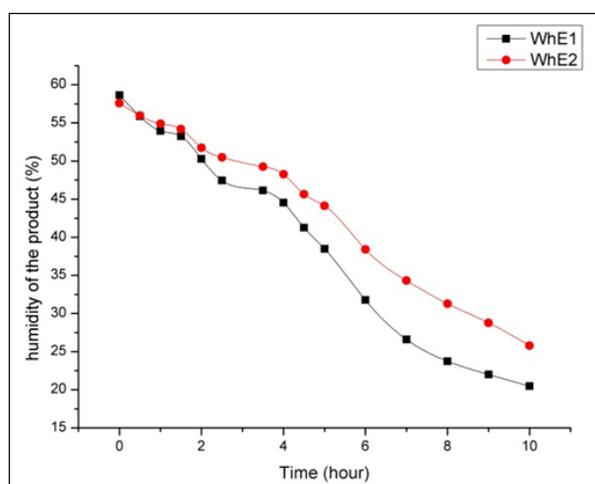


Fig-6: Comparison of the drying kinetics of the first three racks

These curves show the evolution of cassava drying kinetics in an indirect solar dryer with forced convection. The objective of this work was on the homogeneity of the cassava drying speed.

Figure-1 obtained by placing two control products on the tray No. 1 (first rack) closer to the sensor, shows removal rates of the uniform water. This is due to the small difference in energy intake between the product at the entrance of the cabin and the one that ends hurdle. So the conclusion of the first hurdle all products will dry evenly and simultaneously. The drying air flow is normal there. The non-linearity of the curves also show the high dependence of the dryer to solar radiation. These differences are explained by the intermittent phenomena.

Figure-2 shows that the drying starts to be uniform at the end of the drying corresponding to the third drying phase. On this rack, the product upstream with higher humidity, has a greater drying kinetics therefore receives more energy. This finding fits just the removal phase of the open water. By cons, for the bound water, drying remains uniform.

Figure-3 corresponds to the rack 3, described the same as the tray 2. So in this indirect solar dryer, the trays 2 and 3 have the same behavior with respect to drying kinetics.

Figure-4 of the rack 4 also confirms this fact. But cons, consistency is observed after a longer drying time. The initial humidity difference of both products and controls the position of the rack explains this phenomenon. Indeed, the energy input decreases depending on the position of the rack, resulting in a slower rate of drying hurdle this year level. The swapping phenomenon would remedy this problem.

Figure-5 of the tray No. 5, situated in the final position with respect to the intake of the drying gas, describes the same behavior as the first frames. The fact that the two products have the same initials witnesses humidities always show a faster rate for the product at the entrance before reaching a constant evolution corresponding to the removal phase of the bound water.

Figure-6 shows the evolution of the first three racks drying kinetics with time. The product drying rates at the entrance of each rack are compared curves are nearly parallel throughout the drying time. Knowing, energy intake decreases as a function of the position of the screens, a small gap between the trays would have a uniform drying at least with the entry when the hot air supply is laterally and not the bottom to the top.

## CONCLUSION

The experimental results obtained allow us to have a good grasp of the parameters influencing the optimization of kinetics. This type of dryer can be improved by taking into account the effect of the distribution of hot air through the different drying racks. Even within a rack, a difference in drying kinetics is noted and can be resolved by semi-circular permutation during drying. However, the best option is to change the hot air distribution. Indeed, it must allow an identical supply of hot air to all the racks in order to be able to hope for drying with uniform kinetics.

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