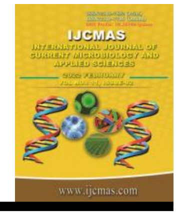
Int.J.Curr.Microbiol.App.Sci (2022) *11*(02): 1-10

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 11 Number 02 (2022)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2022.1102.001

Comparative Study of Tomato (*Solanum lycopersicum*) Drying

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ABSTRACT

The tomato (*Solanum lycopersicum*) is a species of herbaceous plants in the Solanaceae family, native to northwestern South America, widely cultivated for its fruit. A total of 100 g of fresh tomatoes are dried in an oven, in the open air and in a solar dryer, respectively. The kinetics and other parameters were determined: the water content in dry low, the instantaneous drying speed, the average drying temperature, the average relative humidity of tomato, the drying time and the air speed during drying. During solar and oven drying, tomatoes lose water faster, for the same initial (100 g) and therefore, the products receive more energy and heat, compared to drying in the oven 'outdoors. The tomatoes were dried in 1 day in an oven, 3 days in a solar dryer and 6 days in the open air. The shape of the speed curves initially has a short acceleration phase, secondly a rapidly decreasing phase and thirdly, the slopes of the curves tend to soften.

Keywords

Tomato, drying, rural areas, Congo, better quality products

Article Info

Received: 02 January 2022
Accepted: 31 January 2022
Available Online: 10 February 2022

Introduction

The tomato (*Solanum lycopersicum*) is a species of herbaceous plants in the Solanaceae family, native to northwestern South America, widely cultivated for its fruit (Nomenclature, 2006).

It has become an essential element of gastronomy in many countries, such as the Congo. Researchers in the Congo, like those in other countries, are helping to promote the development of the tomato sector by getting involved in the search for scientific and technological solutions to the various problems posed by this sector.

This enthusiasm of researchers for tomatoes can be explained mainly by the fact that the tomato is a vegetable in several ways, particularly in terms of food, medicine and socioeconomics. In terms of food, the tomato is a dietary food, very rich in water

(93 to 95%), low in calories (17 kcal / 100 g), rich in mineral elements and vitamins (A, C and E). Medicinally, the tomato would have a traditional use of phytotherapy in particular thanks to its content in antioxidant carotenoid pigments, and more particularly in lycopene, renowned for its anticancer properties and prevention against cardiovascular diseases.

Socioeconomically, the tomato is cultivated in many countries around the world. Tomato production has two main sectors: tomato for fresh consumption (market tomato) on the one hand and tomato intended for processing and preserving (industrial tomato) on the other hand, also considering production. Food crops which can be significant in certain regions. The aim of this study is to reduce post-harvest losses by developing preservation procedures that increase storage time. The following specific objectives are retained:

Dry the tomato in an oven;

Dry the tomato in the solar dryer;

Air dry the tomato.

Materials and Methods

Plant material

The tomatoes (*Solanum lycopersicum*) studied were purchased at the market in Chateau d'Eau, a district of Brazzaville, shown in figure 1 below and the drying environments shown in figure 2, 3 and 4.

After purchase, the tomatoes are transported to the laboratory to undergo the following operations:

Sorting

Eliminate the softened tomatoes

Trimming

Clean, remove dirt.

Slicing

Cut the large tomatoes into eight parts (1/8 fresh).

Weighing

The large chopped tomatoes are weighed.

Drying

The fresh tomatoes are dried in an oven (60 °C), in the open air and in solar drying.

The tomato preparation diagram is given in figure 5 below

The dried tomatoes collected in the oven are cooled in a desiccator and then packed in plastic jars, labeled and stored on the bench until use. The dry low water content:

The dry low moisture content of the drying tomatoes was determined using the following formula:

$$X = \frac{M1 - M2}{M1}$$

X = Dry bass content (g of water / g of ms)

M1 = Mass of the test sample before drying in grams (g)

M2 = Mass of the test sample after drying in (g)

Instant drying speed

The instantaneous drying speed was determined using the following formula:

$$-\frac{dX}{dt} = \frac{-[X(t + \Delta t) - X(t)]}{\Delta t}$$

With: dX / dt: Drying speed in g of water / g of DM / min. X: Water content on a dry basis (g water / g DM). Δt: Time difference in minutes (min)

Determination of R^2

The coefficient of determination R^2 was found by smoothing the drying curves with Excel. The coefficient of determination R^2 is one of the first criteria to predict the best equation that describes the drying curves.

Using a stainless steel knife the tomato is cut lengthwise into two roughly equal halves. Each tomato half is divided into two equal parts (figure 5); each quarter of a tomato is divided in half.

Drying time

The average time is determined using the following formula:

Dm = D in / N

Dm: Average duration

D in: Duration measured at time t1, t2...... t final

N: Number of measurements performed

Average humidity

The average humidity is determined using the following formula: Hm = H in / N

Hm: Average humidity

H in: Humidity measured at time t1, t2...... t final

N: Number of measurements taken.

Temperature

The average temperature is determined using the following formula:

Tm = T in / N

Tm: Average temperature

T in: Temperature measured at time t1, t2...... t final

N: Number of measurements performed

Average air speed

The average speed is determined using the following formula: V m = V in / N

V m: Average speed

V in: Speed measured at time t1, t2...... t final

N: Number of measurements taken.

Results and Discussion

Drying kinetics

The kinetics were carried out by following the change in the mass of fresh tomatoes over time, as shown in Figure 6 below.

This figure shows the curves for oven drying (60 ° C), solar dryer drying and solar air drying.

This figure shows experimental curves with decreasing rate. The mass drops regularly after 50 min for all the drying operations to stabilize respectively from 300 min, 500 min and 600 min for drying in an oven, drying in a solar dryer and drying in air free. Drying in an oven and in a solar dryer loses a lot of water and stabilizes faster than drying in the open air. This is because of the forced convection for oven drying and the confined hot air for solar dryer drying. Air drying is dependent on variations in environmental factors.

During solar drying and oven drying, tomatoes lose water faster and therefore these products receive more energy and more heat. The loss of mass depends on the drying method and the temperature applied. These curves have the same shapes as those described by Desmorieux *et al.*, (1992). The variation in the drying time is a function of the temperature, which is explained by the fact that the rise in temperature leads to an increase in the intensity of the heat transfer (Bimbenet, 2002).

Similar observations have been reported by Igwe *et al.,* (1999); Njomo (1998); N'dembé (2015).

Oven drying and sun drying are faster than air drying. This is because during the experiment the average dry season temperatures were low and the wind favored air drying.

Table I below shows the values of coefficient of determination R^2 respectively for drying fresh tomatoes in an oven, in a solar dryer and in the open air.

The values of R^2 are high in the cases of air-drying and oven-drying tomatoes, compared to the solar drier. This explains why free air drying receives heat directly through natural convection and oven drying receives heat directly through forced convection.

Duration, temperature, average humidity and average drying speed

Table II opposite shows the values for time, temperature, humidity and average drying speed.

The average time, temperature, humidity and average drying speed are given in Table II below.

The drying time is short for oven drying and sun drying. It is longer for air drying. This can be explained by temperature variations in the case of air drying.

The drying temperature is higher in the oven, and those in the open air and in the solar drier are essentially identical. Oven drying is forced convection. The other two are natural convection. But in the solar dryer circulates hot air.

Humidity values vary from 45.55% for air-drying to 47.47 for solar drying. The hot air circulating in the solar dryer is a determining factor in releasing a high level of humidity.

The air speed is slowed down in the solar dryer and in the oven. Low product dry water content. Figure 7 below shows the results obtained for the water content in low dryness, respectively oven drying, solar drying and open air drying of fresh tomatoes. We note that an increase in temperature results in increased water loss from fresh tomatoes. This leads to a reduction in operating time.

From the analysis of these different curves, it follows first that the water content is practically zero at the end of 360, 510 and 600 minutes respectively for drying in an oven, drying in a solar dryer and drying outdoors.

In this figure, the different experimental curves show an identical pace for the three types of drying; this is decreasing. The drying of tomatoes appears to be governed by the diffusion of water from the bulk to the surface of the sample. These results corroborate those obtained for different plant products (Kouhila, 2001; Bellagha *et al.,* 2002; Kechaou, 2000) and N'dembé (2015).

The higher the temperature in the oven, the shorter the drying time. Likewise, the high temperature in the solar dryer is shorter than the drying time in the open air.

The critical water content is 5.09; 32.33 and 17.18 g of water / g Ms respectively in an oven, in a solar dryer and in the open air.

Table III below reveals the R^2 values, which vary from 99.56% for oven drying, from 98.90% for oven drying, to 98.31% for the solar dryer.

The high R^2 values for air drying and oven drying explain that tomatoes lose a lot of water, this is the free water that evaporates more easily compared to dried ones at the solar drier.

The values of R^2 are high in the cases of air-drying and oven-drying tomatoes, compared to the solar drier. This explains why free air-drying receives heat directly through forced convection and oven drying receives heat directly through natural convection, solar radiation.

Fig.1 Drying process

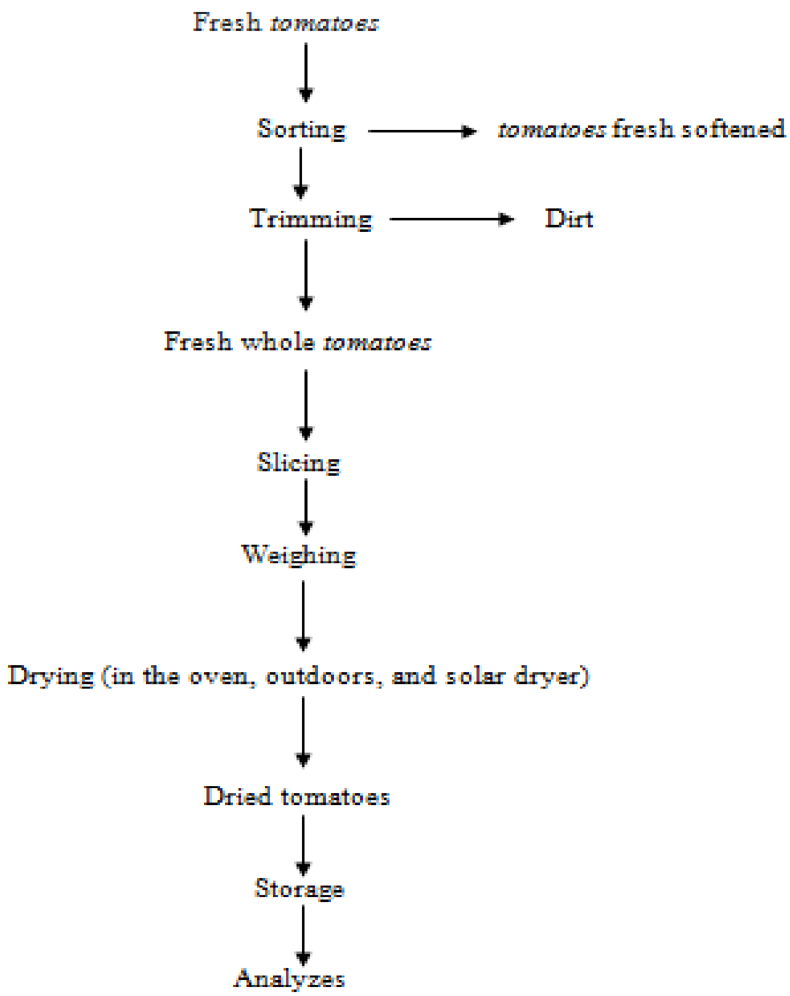


Fig.2

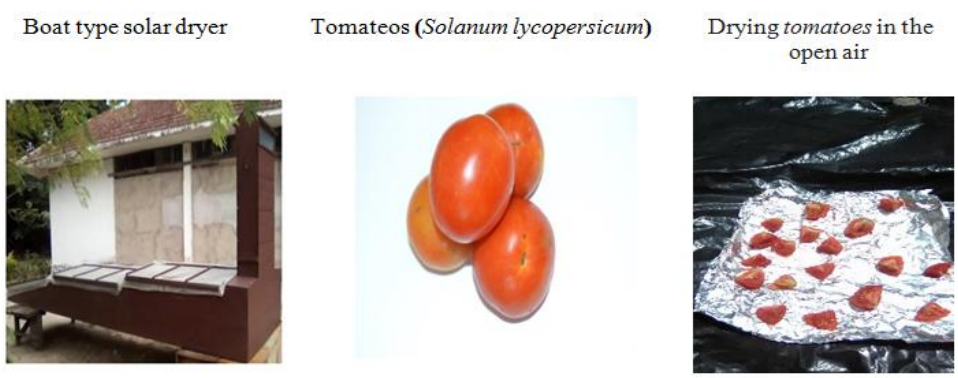


Table.1 Values of coefficient of determination R^2

Coefficient of determination	Drying in the oven	Solar dryer	Drying in the open air
R^2 (%)	99,56 %	98,35 %	99,69 %

Table.2 Time, temperature, humidity and average drying speed values

Drying type	Average duration (mn)	Mean temperature (°C)	Average humidity (%)	Average speed (m / s) de l'air
Solar dryer	240	38.18	47.47	1.40
Drying in the open air	285	38.21	44.55	1.90
Drying in the oven	203.07	60	_	1.2

Table.3 R^2

Coefficient of determination	Drying in the oven	Solar dryer	Drying in the open air
R^2 (%)	98,90 %	98,31 %	99,56 %

Table.4 R^2

Coefficient of détermination	Drying in the oven	Solar dryer	Drying in the open air
R^2 (%)	79,68 %	69,61 %	57,08 %

Fig.3 Drying tomatoes in the oven

Fig.4 Tomato cut into quarters

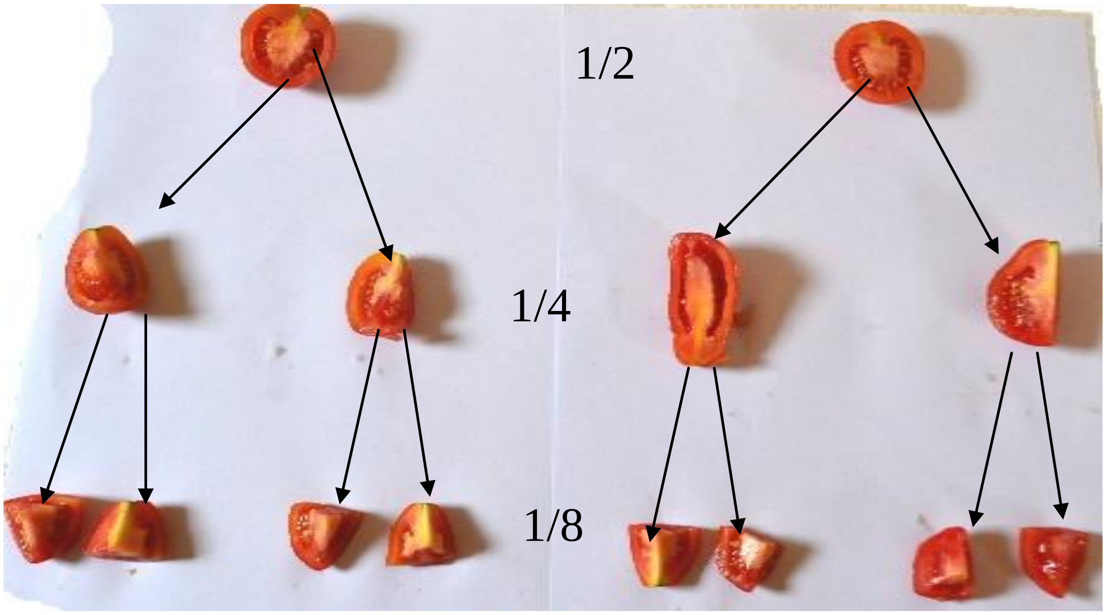


Fig.5 Evolution of the weight of the tomato during the drying process

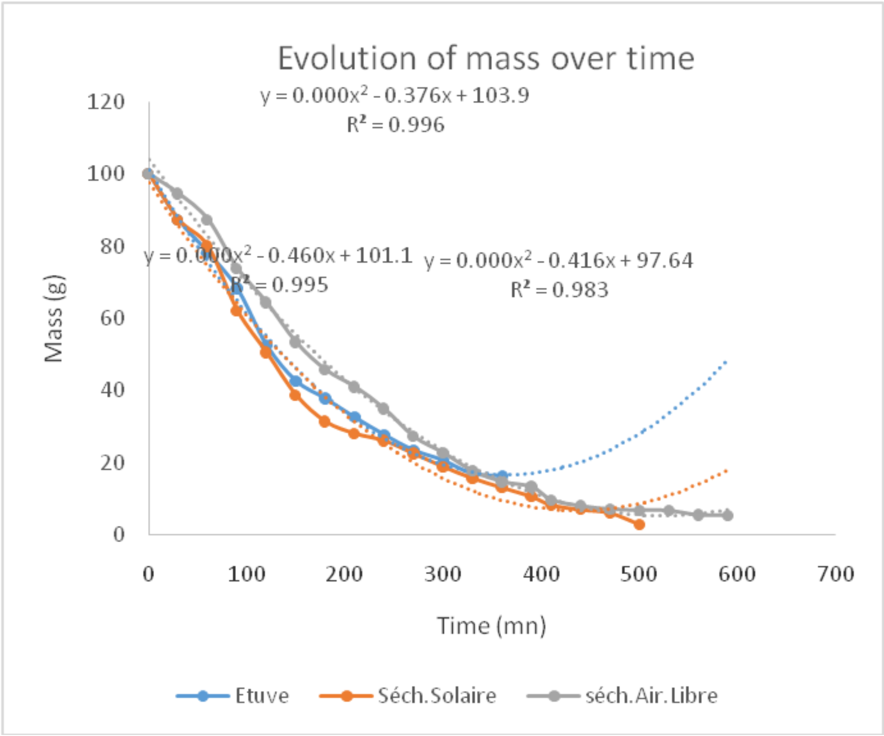


Fig.6 Evolution of the water content over time

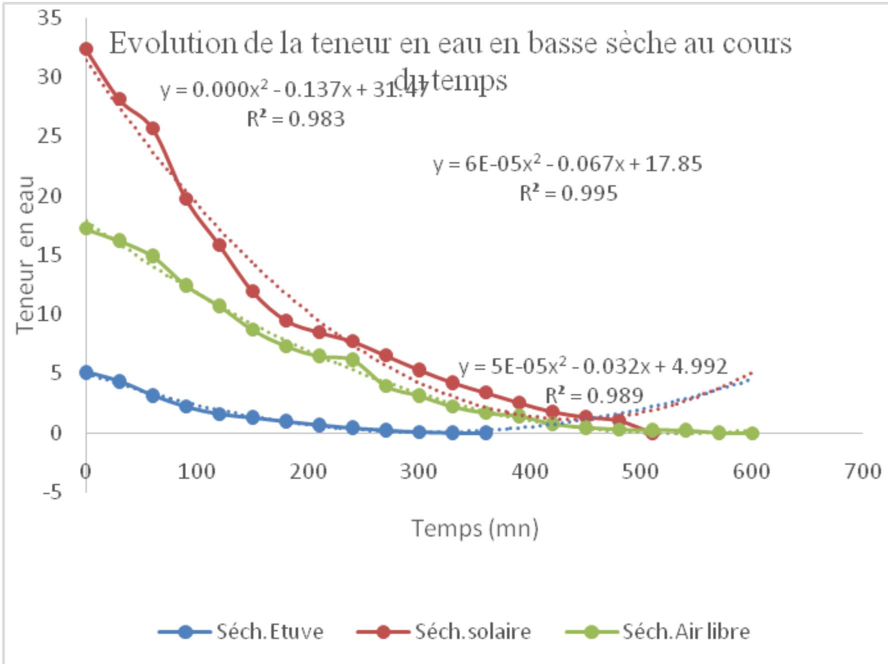
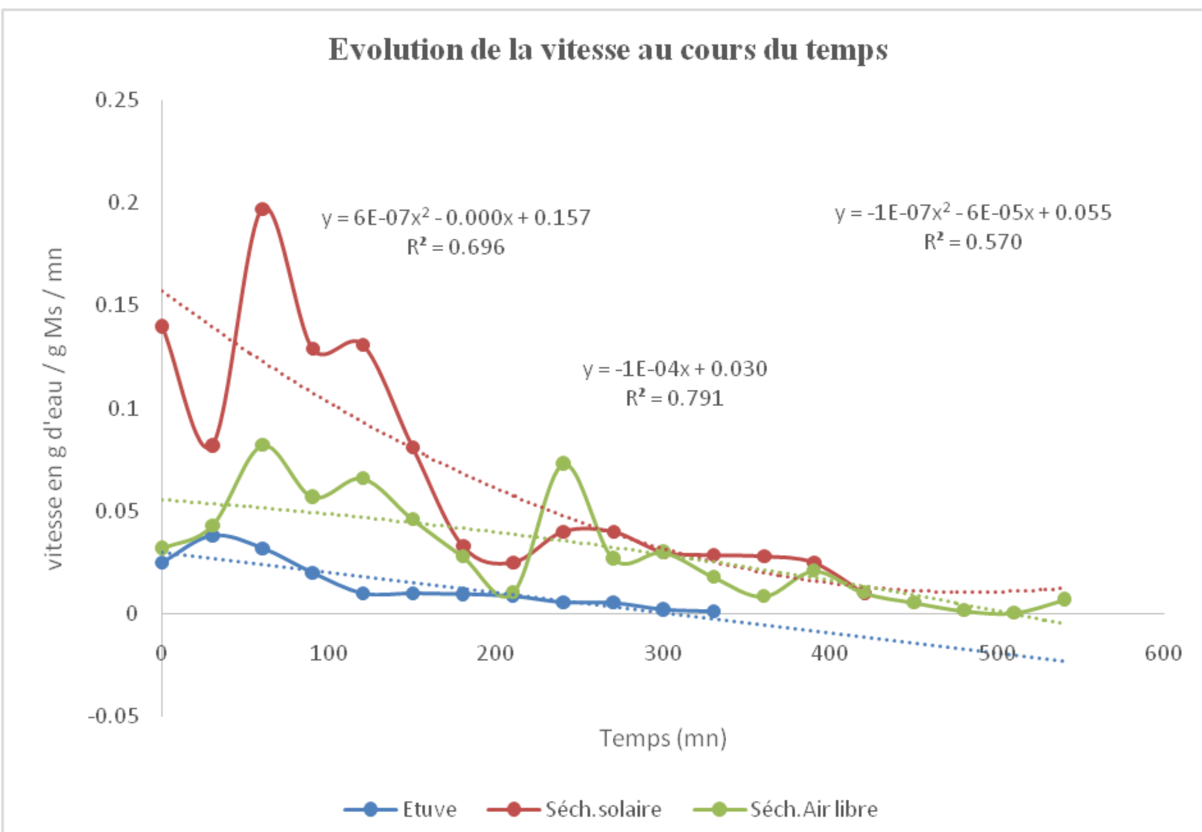


Fig.7 Evolution of the drying speed over time



Drying speed

Figure 8 below shows the drying speed curves (oven, solar dryer and in the open air) as a function of drying time.

The shape of the curves initially has a short acceleration phase; secondly, a rapidly decreasing phase and thirdly, the slopes of the curves tend to soften. This phenomenon reflects the increasing difficulty of extracting bound water, especially in the case of drying in the open air. Many authors have obtained the same curves during the drying of different varieties of plants, such as carrots (Doymaz *et al.*, 2003) and Egg plants (Ertekin and Yaldiz, 2004). This explains the drying speed significantly decreases in air-drying thus delaying the drying. The amplitude of the acceleration phase of the solar drying curve is greater than that of air-drying.

The evaporation rate of surface water from drying in the solar dryer is higher than that in the open air. During the third step, i.e. between 50 and 200 minutes for drying in the solar dryer; 50 to 260 minutes for air drying and 50 to 200 minutes for oven drying the flow of water from the inside of the tomato to the outside is no longer sufficient to maintain the completely wet product surface, a temperature equilibrium is established between the product surface and the surrounding environment which leads to a decrease in the drying speed.

The table below gives the R^2 values of 79.68% for oven drying, 69.61% for the solar dryer and 57.08% for air-drying.
These values show that the water evaporation rate is faster in sun-dried tomatoes and sun-dried tomatoes, that is, bound water.

This study allowed us to better optimize the three types of drying (oven drying, solar dryer drying and open air-drying). Air-drying takes longer than the other two types of drying.

The solar dryer is therefore presented as an alternative because of the free solar radiation to overcome the traditional shortcomings and obtain better quality products capable of meeting the requirements of modern urban consumers.

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How to cite this article:

N'DEMBE BIBALOU Claude, BITA Alain Mercier, ISSALI Emmanuel Auguste and BAZOUNGOULA Alain Armand. 2022. Comparative Study of Tomato (*Solanum Lycopersicum*) Drying. *Int.J.Curr.Microbiol.App.Sci.* 11(02): 1-10. doi: https://doi.org/10.20546/ijcmas.2022.1102.001