Available online at www.elixirpublishers.com (Elixir International Journal)

Agriculture

Elixir Agriculture 182 (2023) 57059 - 57063

Elixir ISSN: 2229-712X

Characterization of Convective Drying of Potato and Taro: Influence of Cutting and Nature of products for Cubic and Cylindrical Shapes

Salifou Ouedraogo[1*], Honoré k. Ouoba[1], Da fatoumata, Yalé abdoul aziz serebe[2], Moussa tarpilga Dit corneille and Betaboalé naon[1]

[1]Laboratoire de Matériaux d'Heliophysique et d'Environnement (LaMHE), Bobo-Dioulasso Université Nazi Boni BP_1091

[2]Laboratoire de Chimie et d'Energies Renouvelables (LaCER), Bobo-Dioulasso, Université Nazi Boni BP 1091

ARTICLE INFO

Article history:
Received: 11 March 2023;
Received in revised form: 30 October 2023;
Accepted: 10 November 2023;

Keywords
Moisture Content,
Potato,
Taro,
Size,
Cylindrical Shape,
Cubic Shape.

ABSTRACT

This present article highlights the influence of the cutting performed on samples of agricultural products as well as their nature of products on the assessment of their convective drying quality. Sweet potato and taro were used for the study. It emerges that the size of the cut plays an important role in the evaluation of mass transfers during convective drying. At 100 minutes of drying and a temperature of 70°C, cubes with dimensions of 1cm, 1.5cm, 2cm, and 2.5cm reached moisture content levels of 40wt.%, 60wt.%, 78wt.%, and 80wt.% of their initial moisture content, respectively. This trend generalizes: the larger the size, the slower the drying. Similarly, the shape slightly influences the transfer process. Furthermore, the experiments showed that at the same temperature and similar dimensions regardless of the cutting shape, taro exhibits greater resistance to transfers than sweet potato.

I. Introduction

Agriculture represents a significant historical territorial resource that contributes to human well-being by providing essential elements such as raw materials, employment, and sustenance (Abou et al., 2018). Tubers, specifically potatoes and taro, hold a crucial role in the diet of Burkina Faso.De par l'accroissement de sa production, la diversité de leurs dérivés et l'importance de la demande sur les marchés nationaux et internationaux, la patate et le taro constituent une culture socialement et économiquement porteuse. Due to the significant post-harvest losses of potatoes and taro, their transformation becomes a necessary strategy for value enhancement. Various solutions have been proposed to address this challenge, including freezing, greenhouse cultivation, and preservation through drying.

The principle of drying involves the simultaneous transfer of heat and mass. The heat from the surrounding environment, as explained by Ouoba et al. (2013), propagates from the outer surface of the product towards its center. As a result, this heat triggers the chemical bonds of the water present in the product, causing it to migrate outward for evaporation (Ouoba et al., 2012). This gradual process leads to a reduction in the moisture content of the product as the transfers take place. Poor control of the drying process results in products that are not well-received by consumers. Despite the diverse body of scientific research on drying, achieving its perfect mastery remains a desired goal.

In the present day, the drying of agricultural products is the subject of numerous studies. For instance, research has been conducted on corn and herring (Ahmed-Zaid A., 1999) the transformation of cassava into various products (DEGNON, 2018) with relatively easy preservation, tomatoes (Hawlader. M. N. A., 1991,), carrots (Techasena O., 1994,) , apples (Zeghmati. B., 1981) and rice (Du Penty- Charbonnier M. A, 1995,) , The drying of ginger, okra, beet pulp, cassava, and red pepper has also been studied (Ahouannou C., 2001,); Potatoes have been examined as well (Youcef-Ali. S., ., 2001,) , as have tubers such as yam and taro(Abou. M et al., 2018). Studies have explored intrinsic parameters in the drying of agri-food products (Ganamé et al., 2020) as well as the significance of the initial surface area on mass and heat transfers (OUOBA et al., 2018).

It should be noted that (par exemple Ouoba K. Honoré., 2013) these studies were conducted on samples for which the exact dimensions and shapes were not considered. Thermal sciences have demonstrated that the behavior of heat depends on numerous factors, such as the shape and dimensions of the body it traverses. Hence, drawing a parallel to the influence of size and shape on mass transfers would be relevant as well. (OUOBA et al., 2012) highlighted the importance of considering the size and shape of samples when evaluating mass transfers during the drying of sweet potatoes.

In this current study, our aim is to explore the trends that the size and nature of products of samples exhibit on the mass transfer process. To accomplish this, we will utilize various shapes, including cubic and cylindrical forms, with differing dimensions for two agri-food products: potatoes and taro. We will evaluate the influence of these parameters on transfers by analyzing the behavior of drying curves at a specific temperature.

II. Materials and Methods

II.1.Materials

In this study, potatoes and taro were purchased from a local market in Bobo-Dioulasso, a city located in the western part of Burkina Faso. These vegetables can exhibit various shapes, ranging from elongated to more rounded. Due to their

Tele:
E-mail address: azizserebe@gmal.com

nearly uniform macrostructure (OUOBA .K.H et al., 2010; Doymaz I, 2002) as well as the uniform initial moisture content within the materials and symmetrical water and heat transfers, we can effectively consider only the shape and size of the sample as parameters (Dissa, et al., 2010). These tubers are transported to the laboratory of GERME & TI (Group for the Study and Research in Energetic Mechanics and Industrial Techniques) at the Nazi BONI University in Bobo-Dioulasso. There, they are washed, peeled, and cut into cubic and cylindrical shapes using a stainless steel knife. In our study, we used cubic samples with respective edge lengths of 1cm, 1.5cm, 2cm, and 2.5cm, as well as cylindrical samples with respective heights and radii of (1cm, 0.25cm), (1.5cm, 0.5cm), (2cm, 0.5cm), and (2cm, 0.75cm).

These samples are then placed in an oven set at a temperature of 70°C. The organoleptic quality of agri-food products is linked to the drying conditions as well as the moisture content of the product at the end of drying, which justifies the chosen temperature.

Throughout the drying process, the samples are periodically removed for mass determination using a precision balance (SARTORIUS, accurate to 0.001g, France) and then returned to the oven. The measurement time is kept short to avoid disrupting the thermodynamic equilibrium.

II.2.Methods

The objective of this study is to determine the moisture content profiles of the material during drying. Drying kinetics are established based on experimental data. Experimentally, we have raw data on the evolution of the sample's mass over time during drying at different temperatures. We process this data using the following approach: The initial moisture content of the product is calculated as the ratio of the total mass of water in the product divided by the mass of the solid material (Ouoba.K., Honoré., 2013), as shown in equation (1).

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

Where X_0: is the initial water content of the product, m_0 is the initial mass of the sample, and m_s is the dry mass of the sample. Moisture content curves were plotted using experimental data as a function of time. From the mass of the sample at time t, we calculate the moisture content (Dissa et al., 2010) using equation (2).

$$\mathrm{X(t)} = \frac{\mathrm{m(t)} - \mathrm{m_s}}{\mathrm{m_s}} \quad (2)$$

Where m(t) is the mass of the sample at time t during drying. Using the value of the dry mass m_s and the mass m(t), we calculate the moisture content X(t) according to equation (2). The kinetics of the moisture content variation at time t, represented by the ratio (X(t))/X_0 derived from the equation (1), results in curves $X(t)/X_0 \rightarrow t$ We plot the relation X(t) → t for each sample (Ouoba et al., 2010). This shows the evolution of the average moisture content over time for a given dimension. The curves X(t) → t, representing the variation of the average moisture content for cubes and cylinders, are actually an average of three curves with acceptable repeatability. We compare the results of experiments conducted simultaneously and within the same oven to mitigate the influence of air velocity and relative humidity, which are important parameters in the drying process's evolution.

III. Results and discussion

In the literature, the drying of agri-food products is typically analyzed through curves depicting the variation of mass or moisture content as a function of drying time (Youcef-Ali et al., 2001; Sahin and Dincer, 2005; Doymaz, 2007). It's worth noting that these curves provide valuable insights into the drying state of the product (Henderson et al., 1961); (Panchariya et al., 2002).

III.1.Influence of size

In order to comprehend the significance of the cutting size, we kept the temperature constant at 70°C while varying these parameters. The temperature is associated with the dehydrator's power.

a. Case of papato

Figure 1(a) represents the moisture content curves of potato samples in cubic shapes with respective edge lengths of 1cm, 1.5cm, 2cm, and 2.5cm, as well as in cylindrical shapes (Figure 1(b)) with respective heights and radii of (1cm, 0.25cm), (1.5cm, 0.5cm), (2cm, 0.5cm), and (2cm, 0.75cm) at a temperature of 70°C. The curves share the same trends and decrease in a similar manner. At a drying time of 100 minutes, the 1cm cube reaches 40wt.% moisture content, the 1.5cm cube reaches 60wt.%, and the 2cm and 2.5cm cubes reach 80wt.% of their initial moisture content. The 2cm and 2.5cm edge length cubes are nearly indistinguishable. For a moisture content of around 10wt.%, the 1cm cube takes 300 minutes, the 1.5cm cube takes 400 minutes, the 2cm cube takes 500 minutes, and the 2.5cm cube takes approximately 600 minutes to reach that level.

For the cylindrical shapes in Figure 1(b), at a drying time equal to or less than 100 minutes, the (1cm, 0.25cm) cylinder is at 15wt.% moisture content, the (1.5cm, 0.5cm) cylinder is at 40wt.%, the (2cm, 0.5cm) cylinder is at 42wt.%, and the (2cm, 0.75cm) cylinder is at 60wt.% of their initial moisture content. The curves of the (1.5cm, 0.5cm) and (2cm, 0.5cm) cylinders are almost indistinguishable. For a moisture content of around 10wt.%, the drying times are approximately 200 minutes, 500 minutes, and 700 minutes for the (1cm, 0.25cm), (1.5cm, 0.5cm), (2cm, 0.5cm), and (2cm, 0.75cm) cylinders, respectively. Generally, larger sizes result in longer drying times.

b. Case of taro

Figure 2(a) illustrates the drying kinetics of cubic taro samples at a temperature of 70°C.

The curves are almost indistinguishable. At a drying time of approximately 100 minutes, the 1cm cube reaches 50wt.% of its initial moisture content, while the 1.5cm cube is at 70wt.%, and the 2cm and 2.5cm cubes are at 80wt.%. For a moisture content of around 10wt.%, the drying times are 250 minutes, 300 minutes, 400 minutes, and 500 minutes, respectively, for the 1cm, 1.5cm, 2cm, and 2.5cm cubes.

Furthermore, in the case of cylindrical shapes in Figure 2(b), the curves decrease rapidly. At T=100 minutes, the (1cm, 0.25cm) cylinder is at 25wt.% of its initial moisture content, while the (1.5cm, 0.5cm) cylinder reaches 50wt.%, the (2cm, 0.5cm) cylinder is at 55wt.%, and the (2cm, 0.75cm) cylinder is at 60wt.%. The drying times are 200 minutes, 250 minutes, 300 minutes, and 380 minutes, respectively, for these different cylindrical samples. It is noticeable that samples with smaller surface areas dry faster; the larger the size, the longer the drying time.

III.2.Influence of the nature of the product

a. Case of cubic shapes

Figure 3 depicts the evolution of reduced moisture content for cubic samples with respective edge lengths of

1cm and 1.5cm for both potatoes and taro at a temperature of T=70°C.

Figure 3(a) shows the reduced moisture content evolution of 1.5cm and 2cm cubic samples for both potatoes and taro at a temperature of T=70°C. At the beginning of drying, the curves exhibit a similar shape, and they decrease in a similar manner. For a residual moisture content around 10wt.%, they take approximately 300 minutes of drying for potatoes and 360 minutes for taro.

In Figure 3(b), the curves are almost indistinguishable, sharing the same trend and decreasing slowly. The drying times are nearly identical; at 400 minutes of drying, they reach only 10wt.% of their residual moisture content. However, there is an observed resistance to transfer in the case of taro.

b. Case of cylindrical shapes

In this paragraph, the moisture contents of cylindrical samples with respective heights and radii of (2cm, 0.5cm) and (2cm, 0.75cm) for both potatoes and taro at a temperature of T=70°C are represented.

Figure 3(c) depicts the evolution of reduced moisture content for cylindrical samples with a height (H=2cm) and radius (R=0.5cm). At the beginning of drying, the curves exhibit a similar shape, and they decrease in a similar manner. For an initial moisture content of around 10wt.%, they take approximately 300 minutes of drying for potatoes and 360 minutes for taro.

The curves in Figure 3(d) represent the normalized moisture content of cylindrical samples with respective heights and radii of (2cm, 0.75cm). It can be observed that for a time between 0 minutes and 100 minutes, the curves are almost indistinguishable. They decrease and reach 10wt.% of their residual moisture content.

IV. Conclusion

This study has demonstrated, through the establishment of moisture content profiles, that size plays an important role during drying. For sweet potato samples with cubic shapes of respective edge lengths of 1cm, 1.5cm, 2cm, and 2.5cm, it is observed that the curves share the same trends and decrease in a similar manner. For a residual moisture content of about 10wt.%, the 1cm cube takes 200 minutes, the 1.5cm cube takes 300 minutes, the 2cm cube takes 390 minutes, and the 2.5cm cube takes approximately 450 minutes for drying.

Furthermore, in the case of cylindrical shapes, for a residual moisture content of about 10wt.%, the drying times are 100 minutes, 250 minutes, and 300 minutes, respectively, for the (1cm, 0.25cm), (1.5cm, 0.5cm), (2cm, 0.5cm), and (2cm, 0.75cm) cylinders. For taro, in the case of cubic shapes, the curves are nearly indistinguishable. For a residual moisture content of around 10wt.%, the drying times are 250 minutes, 320 minutes, 410 minutes, and 480 minutes, respectively, for the 1cm, 1.5cm, 2cm, and 2.5cm cubes.

Moreover, considering both products (potato, taro), the drying kinetics for cubic shapes with edge lengths of 1.5cm and 2cm show that for an initial moisture content around 10wt.%, they take approximately 300 minutes for potatoes and 360 minutes for taro.

Moreover, for cylindrical shapes, the drying times are nearly identical; at 400 minutes of drying, they reach only 10wt.% of their initial moisture content. However, there is observed resistance to transfer in the case of taro.

Additionally, for cylindrical shapes with respective heights and radii of (2cm, 0.75cm), it can be observed that the curves are nearly indistinguishable. They decrease and reach 10wt.% of their moisture content in just 100 minutes.

It is evident that smaller-sized samples exhibit higher drying kinetics compared to larger-sized ones. The smaller the size, the shorter the drying time. The drying rate of sweet potato is higher than that of taro due to the significant amount of gum present in sweet potato, which has a considerable influence on the drying duration.

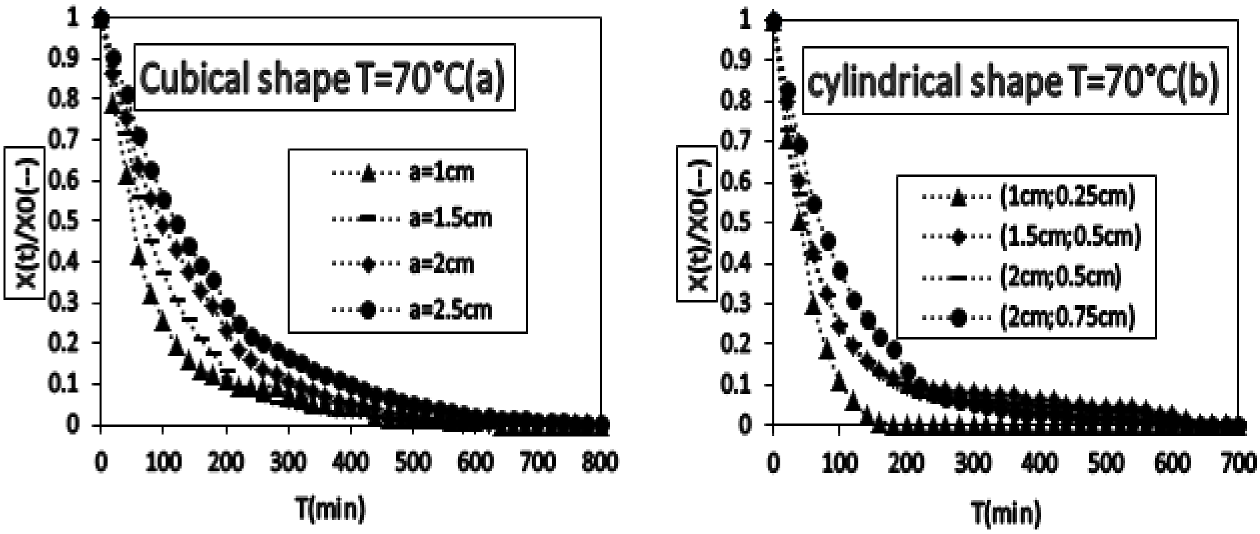

Fig 1. Effect of size on drying kinetics of potato samples: cubic (a) and cylindrical (b)

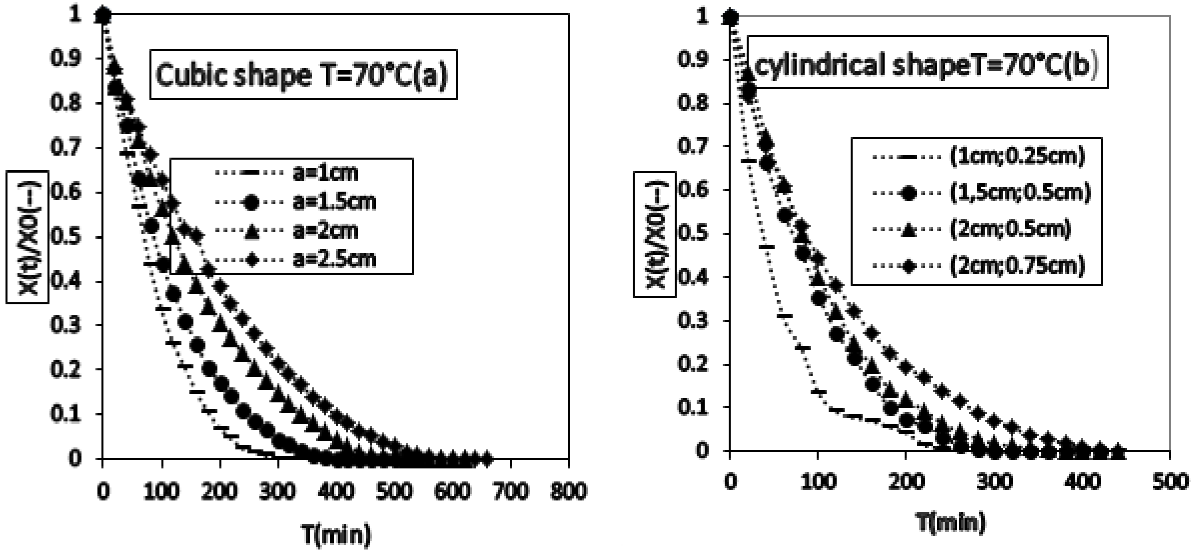

Fig 2. Effect of size on drying kinetics of taro samples: cubic (a) and cylindrical (b)

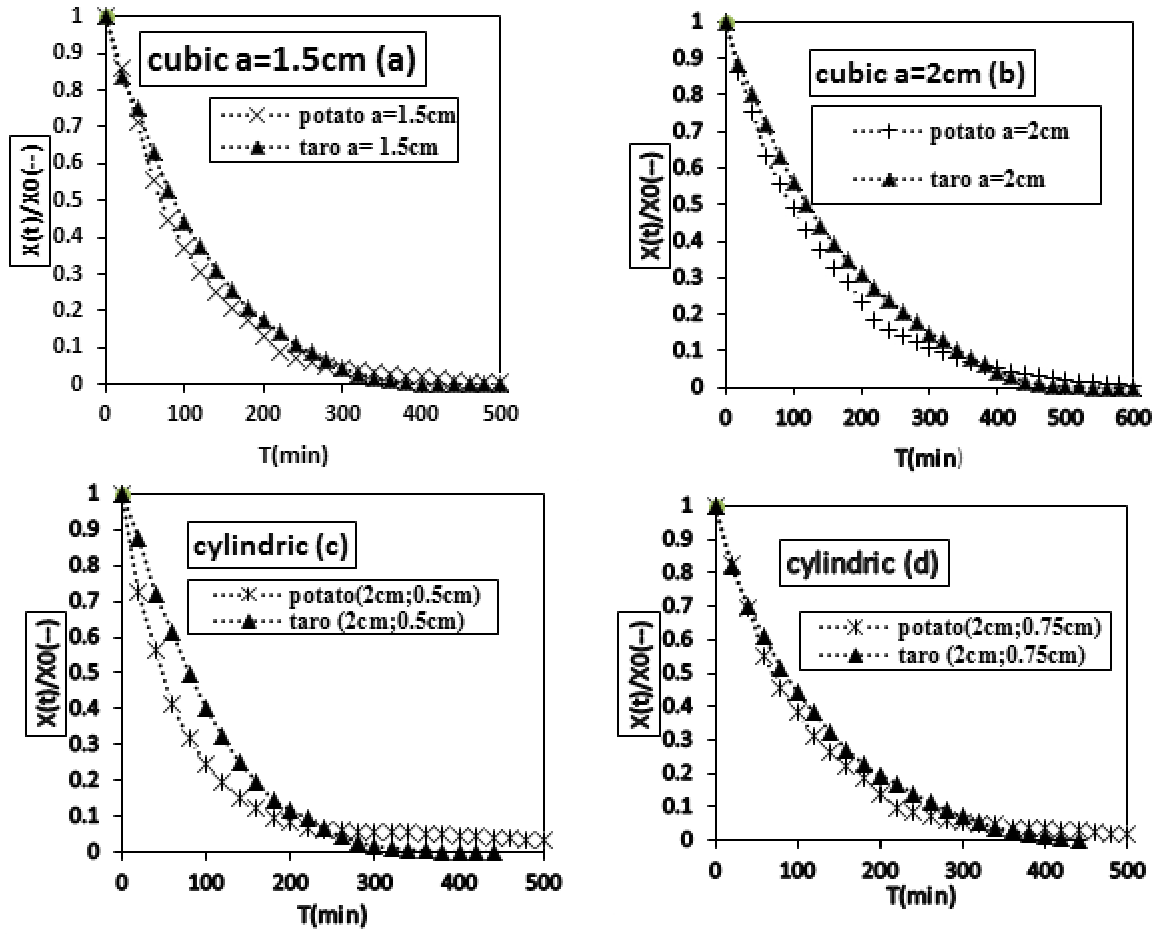

Fig 3. Influence of the nature of products on the drying of cubic samples (a), (b) and cylindrical samples (c), (d)

V. References

Abdou-Salam, G., Honore, O. K., & François, Z. (2020). Taking into Account the Complex Nature and the Intrinsic Parameters of Agro-Food. Journal of Biophysical Chemistry, 11(01), Article 01. https://doi.org/10.4236/jbpc.2020.111001

Abou, M., Yabi, I., Yolou, I., & Ogouwale, E. (2018). Caractérisation des systèmes de production sur les sites d'aménagements hydro-agricoles dans le doublet Dangbo-Adjohoun au sud du Bénin. International Journal of Biological and Chemical Sciences, 12(1), Article 1. https://doi.org/10.4314/ijbcs.v12i1.36

Ahmed-Zaid, A. (1999). Optimisation des capteurs solaires plans à air: Application au séchage de produits agricoles et de la pêche. Valenciennes.

Ahouannou C., A. Etude du séchage de produits agroalimentaires tropicaux: cas du manioc, du piments ,. thèse doctorat, Université Normale de Benin, : s.n., 2001,

Degnon, G. R., Konfo, T. C., Adjou, S. E., & Dahouenon-Ahoussi, E. (2018). Evaluation des conditions de production, de la qualité physico-chimique et microbiologique des cossettes de manioc (Manihot esculanta Crantz) dans la commune de Bassila (Nord-Bénin). International Journal of Biological and Chemical Sciences, 12(3), 1528‑1541.

Dissa, A. O., Desmorieux, H., Savadogo, P. W., Segda, B. G., & Koulidiati, J. (2010). Shrinkage, porosity and density behaviour during convective drying of spirulina. Journal of food Engineering, 97(3), 410‑418.

Doymaz, I. (2007). Air-drying characteristics of tomatoes. Journal of Food engineering, 78(4), 1291‑1297.

Doymaz, I., & Pala, M. (2002). Hot-air drying characteristics of red pepper. Journal of food engineering, 55(4), 331‑335.

Du Penty- Charbonnier M. A. Etudes des transferts de chaleur et de masse en milieu granulaire : Application au séchage du riz. Paddy, thèse doctorat, Université de Poitiers, ed. Springer-verlag. : s.n., 1995

François, Z. (2012). Profils des teneurs en eau de la patate douce durant son séchage convectif. Rev.CAMES-Série A, 13, 201‑205.

Hawlader, M. N. A., Uddin, M. S., Ho, J. C., & Teng, A. B. W. (1991). Drying characteristics of tomatoes. Journal of food engineering, 14(4), 259‑268.

Henderson, S. M. (1961). Grain drying theory, I. Temperature effect on drying coefficient. J. Agr. Eng. Res., 6(3), 169‑173.

Honoré, O. K., François, Z., Raguilignaba, S., Aboubacar, T., & Hélène, D. (2014). Characterization of okra convective drying, influence of maturity. Food and Nutrition Sciences, 2014.

Honoré, O. K., Hélène, D., & François, Z. (2018). What Process Optimizes Convective Drying of Farm Products with Complex Constitution: Case of Okra (Abelmoschus esculentus). Journal of Agricultural Chemistry and Environment, 8(1), 14‑22.

Ouoba K.H., Zougmoré.F., Naon B., DESMORIEUX H., Profile des teneurs en eau de la patate douce Durant son séchage convective. Profile of sweet potato water content during its convective drying.S.I., Rev. CA MES-Série A (2012), pp201-205, 2012.

Ouoba, K. H., Ganame, A.-S., & Zougmore, F. (2021). Research of the Characteristic Dimension of the Transfers during the Convective Drying of the Sweet Potato for the Parallelepipedic and Spherical Shapes. Advances in Materials Physics and Chemistry, 11(12), Article 12. https://doi.org/10.4236/ampc.2021.1112022

Ouoba, K. H., Zougmore, F., & Desmorieux, H. (2019). Effect of Initial Size and Shape Importance on Masse Transfer during Convective Drying. Food and Nutrition Sciences, 9(12), 1514.

Panchariya, P. C., Popovic, D., & Sharma, A. L. (2002). Thin-layer modelling of black tea drying process. Journal of food engineering, 52(4), 349‑357.

Sahin, A. Z., & Dincer, I. (2005). Prediction of drying times for irregular shaped multi-dimensional moist solids. Journal of food engineering, 71(1), 119‑126.

Techasena, O., Lebert, A., & Bimbenet, J. J. (1992). Simulation of deep bed drying of carrots. Journal of food Engineering, 16(4), 267‑281.

Youcef-Ali, S., Messaoudi, H., Desmons, J. Y., Abene, A., & Le Ray, M. (2001). Determination of the average coefficient of internal moisture transfer during the drying of a thin bed of potato slices. Journal of food engineering, 48(2), 95‑101.

Zeghmati, B. (1981). Modélisation informatique d’un séchoir à effet de serre pour fruits et légumes.