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Drying Kinetics of African Eggplant (*Solanum aethiopicum*) using Cabinet Dryer

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ABSTRACT

African eggplant (Solanum aethiopicum) is a key vegetable in African agriculture and cuisine, valued for its nutritional and economic significance. However, its high moisture content leads to rapid post-harvest deterioration. This study evaluates the effects of microwave pretreatment on the drying kinetics of African eggplant. Slices were divided into two groups: one pretreated with microwave power for 600 W at 2 min and a control. Drying was conducted using a cabinet dryer at drying temperatures of 40, 45, and 50 °C and slice thicknesses of 3, 6 and 9 mm. The moisture content and drying rates were monitored. Results showed that increasing temperature significantly accelerated drying, reducing overall drying time. Microwave pretreatment enhanced drying efficiency compared to the control. Thin slices (3 mm) exhibited the fastest drying rates due to reduced internal resistance to moisture migration, whereas thicker slices (9 mm) displayed slower drying kinetics. These findings provide insights into optimising drying parameters for improved preservation of African eggplant, contributing to reducing post-harvest losses and enhancing shelf life.

INTRODUCTION

African Eggplant (*Solanum aethiopicum*), commonly known as "garden egg," is a staple vegetable in many African countries, highly valued for its culinary versatility, nutritional benefits, and economic importance. It is consumed in various forms, including fresh, cooked, and dried, and is often used in traditional dishes and sauces. African eggplant is known for its rich content of vitamins, minerals, and dietary fibers, making it a vital component of the diet in many African communities (Popoola *et al*., 2020). Moreover, African eggplants have been recognized for their potential in improving food systems and combating malnutrition, especially in regions with prevalent micronutrient deficiencies (Ojiewo *et al*., 2020). Despite its importance, research on post-harvest processing and preservation methods, such as drying, remains limited. Addressing this gap can significantly enhance the shelf life and quality of African eggplant, ultimately supporting food security and economic stability in the region (Musa and Oyedele, 2020).

Drying is a crucial method for preserving vegetables, significantly extending their shelf life by reducing their moisture content to levels that inhibit the growth of spoilage microorganisms and enzymatic activity (Doymaz, 2018). This process prevents deterioration and retains essential nutrients, making dried vegetables a valuable source of vitamins, minerals, and dietary fiber. Given the challenges of food insecurity and post-harvest losses, particularly in developing regions, drying offers an efficient and cost-effective solution to enhance food availability and reduce waste (Karam *et al*., 2019). Cabinet drying involves placing vegetables in an enclosed chamber where heated air is circulated to achieve uniform drying (Kumar *et al*., 2020) and allows for better control over drying parameters such as temperature, air velocity, and humidity, leading to consistent and high-quality dried products. It is widely used in small-scale and industrial applications due to its reliability and effectiveness (Yousefi *et al*., 2021).

Cabinet drying, also known as hot air drying, involves placing vegetables in an enclosed chamber where heated air is circulated to achieve uniform drying (Kumar *et al*., 2020). This method allows for better control over drying parameters such as temperature, air velocity, and humidity, leading to consistent and high-quality dried products. Cabinet drying is widely used in both small-scale and industrial applications due to its reliability and effectiveness (Yousefi *et al*., 2021). This study is therefore carried out to determine the drying characteristics of microwave pretreated and untreated eggplant slices using a cabinet dryer.

MATERIALS AND METHODS

Materials

African eggplant (Solanum aethiopicum) was purchased from a local market in Ogbomoso, Oyo State, Nigeria. Cabinet dryer and other apparatus (sensitive weighing balance, stainless-steel knife, thermometer, bowl, tray, and distilled water) were obtained from Ibrahim Owoduni Food Processing Laboratory, Ladoke Akintola University of Technology, Ogbomoso.

Sample Preparation

African eggplant was sorted and washed to remove extraneous materials. They were cut using a sharp knife into slice thicknesses of 3, 6 and 9 mm and were divided into three portions. The first portion of the sample was untreated, while the second portion was pretreated using microwave at power level 600 W for 120 s before drying at 40, 45 and 50 °C.

Drying Procedure

The pretreated eggplant slices were spread uniformly in drying trays in a monolayer and placed in a cabinet dryer. Before commencement of drying of the eggplant slices, the dryer was operated for at least 1 h for the steady state condition within the dryer to be obtained before the drying of the samples. Drying of the samples was conducted at drying temperatures of 40, 45 and 50 °C and the drying was considered to have ended when three consecutive weights of the samples became constant. Hot-air orientation was horizontal over the surface and the perforated bottom of the drying material. The drying experiments were carried out in triplicate and sample weights were measured at regular time intervals during the drying process using a digital balance (PH Mettler) having an accuracy of ±0.01 g.

Experimental Design

A 3 x 3 factorial design was used for the cabinet drying method since we have factors such as slice thickness (3, 6, and 9 mm) and microwave pretreatment time (120 s).

Drying Kinetics

The initial moisture content of the sample before drying was determined using AOAC (2010). The kinetics involved in the drying of the samples was calculated using Equation 1:

$$MC = \frac{W_i - W_d}{W_i} \times 100 \quad (1)$$

where MC is the moisture content, Wi is the initial mass of the sample before drying, and Wd is the mass of the sample at time t.

$$\text{Moisture Ratio } (MR) = \frac{M - M_e}{M_i - M_e} \quad (2)$$

where, MR is the dimensionless moisture ratio, M, Me, and Mi are the moisture content at any time t, equilibrium moisture content and initial moisture content, respectively.

$$\text{Drying rate (DR)} = \frac{m_t - m_{t-1}}{t} \quad (3)$$

Statistical Analysis

The data analysis was carried out based on the means from the data obtained. All drying experiments were conducted in triplicate, and the mean values of the results were taken. The one-way analysis of variance (ANOVA) of the data was carried out using Statistical Package for Social Sciences (SPSS) Version 22.0 to find out whether there was any significant variation in the means ($p<0.05$).

RESULTS AND DISCUSSION

Determination of Drying Rate and Drying Rate Curve

A plot of moisture content against time resulted in the drying curve, as shown in Figures 1 - 3, while a plot of drying rate against average moisture content gave the drying rate curve, as shown in Figures 4 - 6.

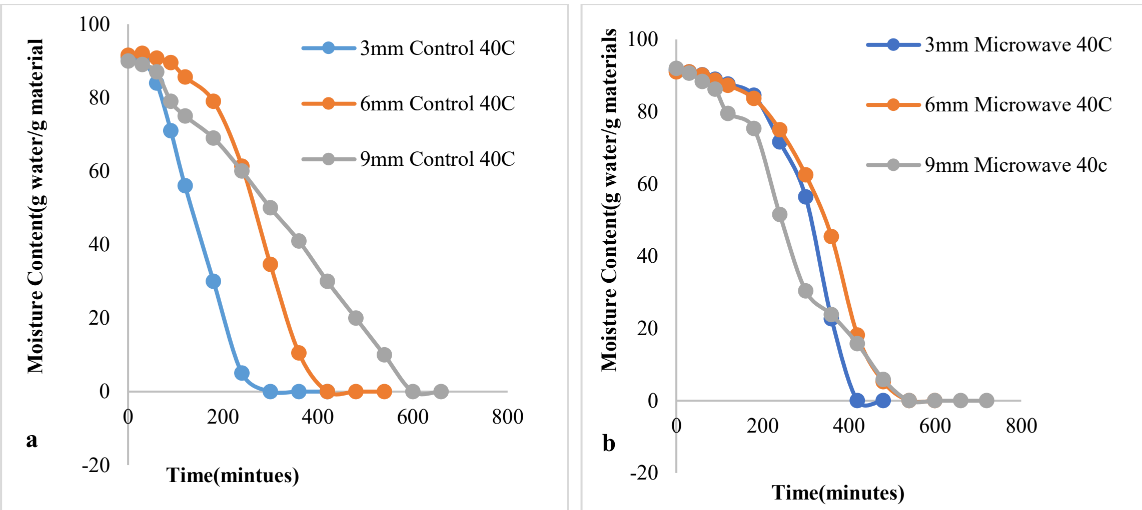

Figure 1: Drying curves for eggplant slices cabinet dried 40 °C for [a] Control [b] Microwave

Figures 1 - 3 show the drying curves for African eggplant using different drying temperatures (40, 45 and 50 ºC). At 40 °C, the drying rate of African eggplant shows a consistent pattern across different samples in Figure 1. For the control samples, the drying rate is relatively slow due to the lower temperature, resulting in a prolonged drying period. The drying rate curves indicate that moisture removal occurs steadily over time, with a noticeable decrease in rate as the moisture content approaches equilibrium. This trend aligned with the findings of Musa and Oyedele

(2020), who reported that lower drying temperatures generally lead to slower moisture removal due to reduced vapour pressure differences driving the drying process.

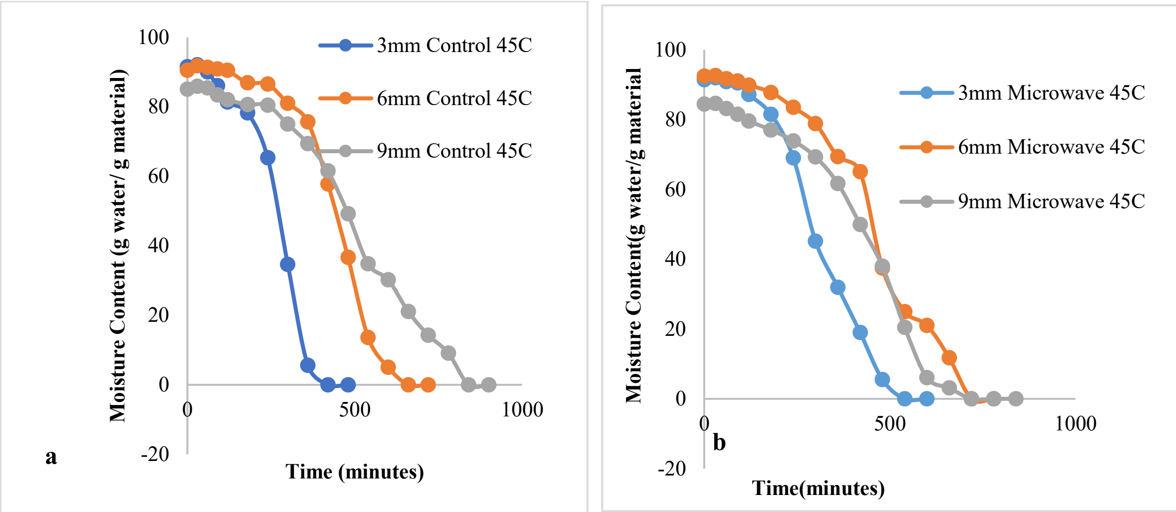

Figure 2: Drying curves for eggplant slices cabinet dried 45 °C for [a] Control [b] Microwave

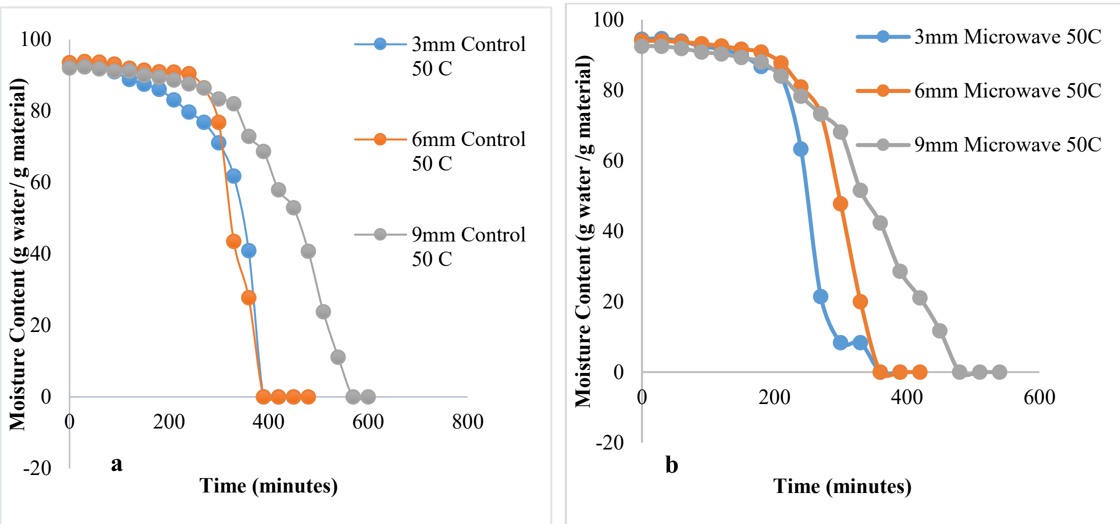

Figure 3: Drying curves for eggplant slices cabinet dried 50 °C for [a] Control [b] Microwave

The drying rate at 45 °C for control samples increases compared to 40 °C, as shown in the drying rate curve. The increased temperature enhances the kinetic energy of water molecules, facilitating faster evaporation. However, the drying rate still gradually decreases as the moisture content lowers. This pattern is typical for convective drying processes, where the initial phase is characterized by a constant drying rate followed by a falling rate period, as noted by Ekechukwu (2018). Microwave pretreatment at 45°C in Figure 2 results in the highest drying rate among the methods tested at this temperature. The rapid initial drying phase is attributed to the efficient energy absorption by water molecules, promoting faster moisture diffusion. This result aligned with the findings by Chavan *et al*. (2019), who reported significant improvements in drying rates with microwave pretreatment.

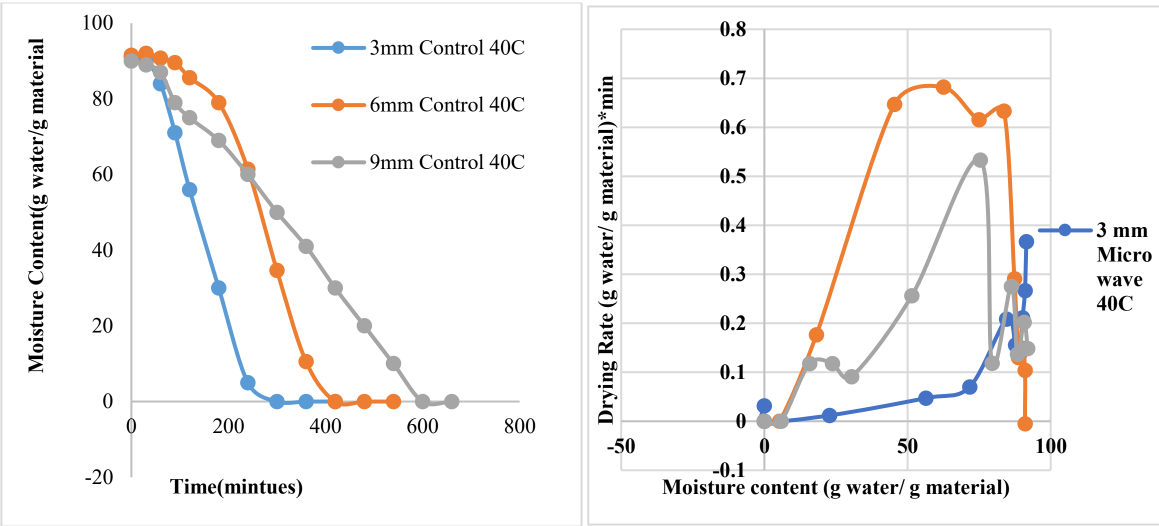

Figure 4: Drying rate curve for drying African eggplant at 40 °C for [a] Control [b] Microwave

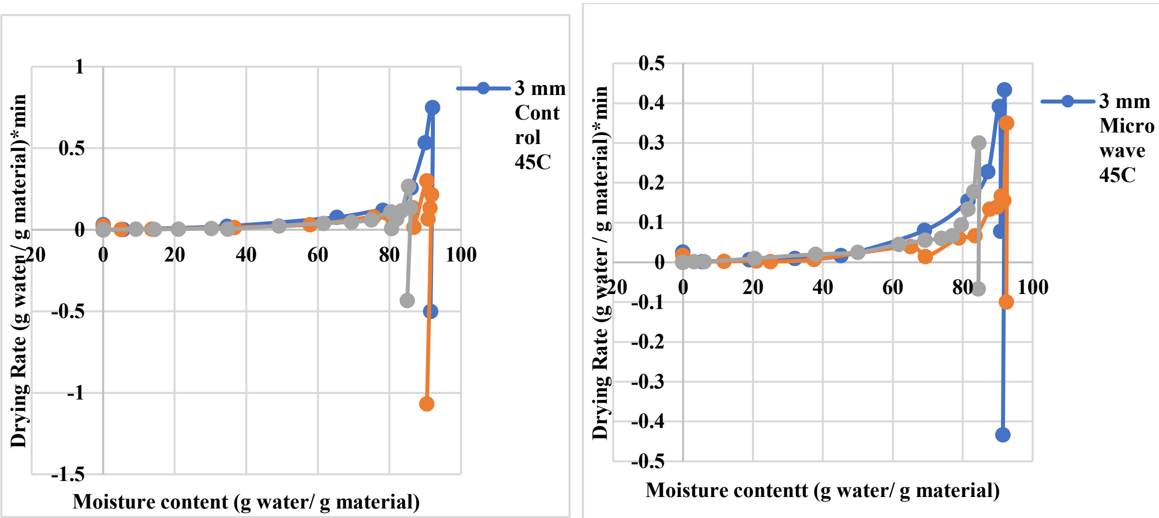

Figure 5: Drying rate curve for drying African eggplant at 45 °C for [a] Control [b] Microwave

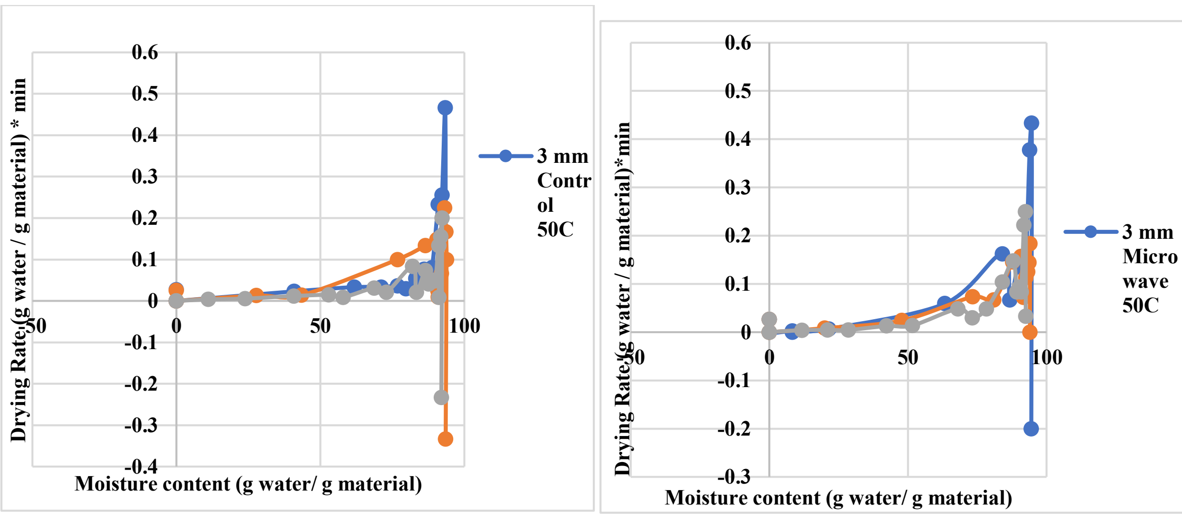

Figure 6: Drying rate curve for drying African eggplant at 50 °C for [a] Control [b] Microwave

The drying rates for both samples increased significantly at the drying temperature of 50 °C. The control samples (Fig. 3) dry more quickly than at lower temperatures, as shown by the drying rate curve in Figure 3. Higher temperatures increase the vapour pressure difference between the vegetable surface and the drying air, enhancing moisture evaporation. This observation is consistent with the principles outlined by Doymaz (2018), where higher drying temperatures lead to faster drying rates due to increased thermal energy. Microwave pretreatment in Figure 3 at 50 °C shows the highest drying rate among the conditions tested, as shown in the drying rate curve. The rapid moisture removal is due to the high energy input from microwave treatment, which accelerates moisture diffusion and evaporation. This finding agreed with the study by Akpinar and Bicer (2021), which demonstrated the effectiveness of microwave pretreatment in improving drying rates at elevated temperatures.

Effect of Slice Thickness on Drying Conditions for African Eggplant

The drying kinetics of African eggplant slices, as depicted in Figures 4 - 6, demonstrate significant variations based on the slice thickness. The three thickness levels examined in the study (3, 6 and 9 mm) exhibit distinct drying behaviours influenced by the drying temperature and pretreatment applied.

Thin Slices (3 mm)

Thin slices of African eggplant (3 mm) exhibit the fastest drying rates across all temperatures. As shown in Figures 4, 5 and 6 for cabinet drying at 40, 45 and 50 °C, respectively, thin slices reach equilibrium moisture content quicker than thicker slices. This rapid drying is primarily due to the shorter distance for moisture to travel from the interior to the surface, resulting in more efficient moisture removal. The drying rate curves highlight that thin slices initially maintain a relatively high drying rate, which decreases significantly as the moisture content reduces. These observations agreed with the findings of Chavan *et al*. (2019), who reported that thinner vegetable slices generally dry faster due to reduced internal resistance to moisture migration. For pretreatment, thin slices subjected to microwave pretreatment in Figures 4 – 6 show exceptionally high initial drying rates. The rapid initial moisture loss can be attributed to microwave treatment's efficient energy absorption and heating, accelerating the drying process. This is consistent with the study by Yousefi *et al*. (2021), which demonstrated that microwave pretreatment enhances drying rates significantly by increasing internal temperature and vapour pressure.

Medium Slices (6 mm)

Medium slices (6 mm) of African eggplant display intermediate drying rates compared to thin and thick slices. Figures 4 and 6 show the drying behaviour of 6 mm slices at different temperatures, indicating a balanced drying rate that benefits from surface area and internal moisture migration dynamics. The drying rate curves depict a noticeable decline in drying rate as the process progresses, typical of the falling rate period observed in convective drying. The pretreatment method again influenced the drying kinetics significantly. The microwave pretreated medium slices show superior drying performance, further corroborated by the rapid initial drying rates depicted in Figures 4 and 6.

Thick Slices (9 mm)

Thick slices (9 mm) of African eggplant exhibit the slowest drying rates among the three thickness levels, as evidenced by Figures 4 and 7. The increased thickness results in a greater distance for moisture to travel, leading to slower internal moisture diffusion and longer drying times. The drying rate curves for thick slices reflect a gradual decline in drying rate, highlighting the increased resistance to moisture movement within the thicker slices. This observation is consistent with the research by Ekechukwu (2018), which states that thicker slices inherently have lower drying rates due to higher internal moisture diffusion resistance. For thick slices, pretreatment effects are more pronounced. Microwave pretreatment in Figures 4 and 7 significantly enhances the drying rate of thick slices compared to the control sample, as shown in the corresponding drying rate curves. The improved drying performance is due to the volumetric heating effect of microwaves, which effectively reduces internal moisture resistance and accelerates drying. This finding aligned with the study by Mogaji and Akinyemi (2021), who reported that microwave pretreatment is particularly effective for thicker vegetable slices, resulting in more uniform and faster drying.

Effect of Pretreatment Methods

The pretreatment method significantly impacts the moisture diffusivity of African eggplant. Microwave pretreatment at 600 W for 2 min was employed to alter the structural properties of the eggplant slices, facilitating easier moisture migration. Microwave pretreatment results in the highest adequate moisture diffusivity values among the pretreated and untreated samples. The application of microwave energy causes rapid heating and vapourization of water within the eggplant slices, creating micro-channels and pores that enhance moisture migration. This effect is particularly pronounced at higher drying temperatures, where the combined energy input from the drying air and microwaves significantly boosts the moisture diffusivity. The study by Yousefi *et al*. (2021) corroborates these findings, demonstrating that microwave-assisted drying techniques can substantially increase the moisture diffusivity by inducing structural changes that facilitate moisture transport.

CONCLUSION

The research on the drying kinetics of African eggplant using cabinet drying methods has provided valuable insights into optimising drying processes to preserve the vital vegetable's quality and nutritional value. The study examined the effects of different drying temperatures (40, 45 and 50 °C) and microwave pretreatment method on African eggplant slices' drying behaviour and kinetics. It can be concluded that higher drying temperatures significantly enhance the drying rate and reduce overall drying time. Microwave pretreatment consistently yielded the highest drying rate values across all temperatures, demonstrating its effectiveness in facilitating rapid moisture removal. The study confirmed that thinner slices (3 mm) dry faster than medium (6 mm) and thick (9 mm) slices due to the shorter distance for moisture to travel. The relationship between slice thickness and drying kinetics underscores the importance of optimising slice dimensions in drying parameters to achieve efficient and uniform drying. Overall, the research highlights the significance of selecting appropriate drying temperatures, slice thicknesses, and pretreatment methods to optimise the drying of African eggplant. These findings contribute to developing efficient drying protocols that enhance the shelf life, nutritional quality, and economic value of African eggplant, supporting food security and sustainable agricultural practices in regions where this vegetable is a dietary staple.

REFERENCES

Akpinar, E. K. and Bicer, Y. (2021). Mathematical Modeling of Thin Layer Drying of Vegetables. *Journal of Food Engineering*, 126, 297-306.

AOAC. (2010). Official methods of analysis of AOAC International (19th ed.), Washington, D.C., USA.

Chavan, S., Amarowicz, R. and Alamed, J. (2019). Solar Drying of Fruits and Vegetables: Opportunities and Challenges. *Renewable and Sustainable Energy Reviews,* 98, 321-331.

Doymaz, İ. (2018). Evaluation of Some Drying Models for Drying of Carrot Slices. *Energy Conversion and Management*, 43(10): 1733-1741.

Ekechukwu, O. V. (2018). Review of Solar-energy Drying Systems I. An Overview of Drying Principles and Theory. *Energy Conversion and Management*, 40(6), 615-655.

Karam, M. C., Petit, J., Zimmer, D. and Baudelaire, M. (2019). Effects of Drying and Grinding in Production of Fruit and Vegetable Powders: A Review. *Journal of Food Engineering*, 188, 32-46.

Kumar, C., Karim, M. A. and Joardder, M. U. H. (2020). Effect of Different Drying Methods on Vegetable Drying: A Review. *Drying Technology*, 38(15), 1907-1915.

Mogaji, T. S. and Akinyemi, A. A. (2021). Phytochemical Composition and Antioxidant Properties of Some Selected Medicinal Plants in Nigeria. *Journal of Medicinal Plants Research*, 15(2), 45-52.

Musa, M. F. and Oyedele, D. J. (2020). Influence of Drying Methods on the Quality of African Vegetables. *Journal of Agricultural Engineering and Biotechnology*, 45(2), 180-190.

Ojiewo, C. O., Keatinge, J. D. H., Hughes, J. A., Tenkouano, A. and Mavlyanova, R. (2020). Diversifying Food Systems in the Pursuit of Sustainable Food Production and Healthy Diets. *Acta Horticulturae*, 1272, 19-28.

Olajire, A. S., Ogunlakin, G. O., Olapade, T. P., and Onifade, T. B. (2022). Effect of different drying methods on the drying kinetics and proximate composition of garden egg. *Asian Journal of Advances in Research*, 5(1), 87-97.

Popoola, J. O., Timko, M. P., and Obembe, O. O. (2020). Genetic Diversity and Population Structure of African Eggplant (*Solanum aethiopicum*) based on Microsatellite Markers. *Plant Genetic Resources Characterization and Utilization*, 18(1), 21-30.

Yousefi, S., Emam-Djomeh, Z., and Mousavi, S. M. (2021). Comparison of Hot Air, Infrared and Combined Hot Air-Infrared Drying Methods on Drying Kinetics and Quality Characteristics of Vegetables. *Journal of Food Processing and Preservation*, 45(1), e15022.