ORIGINAL RESEARCH ARTICLE

Effects of different pretreatments on thin-layer drying kinetics, vitamin A retention and rehydration of orange-fleshed sweet potato slices

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ABSTRACT

Orange-fleshed sweet potato (OFSP) is a bio-fortified sweet potato with a high beta-carotene content. OFSP deteriorates rapidly due to its high moisture content. Conventional air drying is one of the most common methods employed but has the disadvantage of low rates of moisture removal, hence the longer drying time, which affects the quality of the final product. Pretreatments prevent quality deterioration and hasten the drying rate. This study investigated the effects of different pretreatments on thin-layer drying kinetics and the quality of OFSP slices. Three-mm-thick OFSP slices were pretreated using three different pretreatments: lemon juice, salt solution, and hot water blanching (HWB). Pretreated slices were dried in a solar dryer. Data collection (weight, temperature, relative humidity, and solar radiation) was done at 1-hour intervals. Four mathematical models (Page, Logarithmic, Modified Page, and Henderson and Pabis) were fitted to the experimental data. Also, the quality parameters of vitamin A and rehydration were investigated. The dryer inside temperatures and relative humidity ranged from 26.93–44.53 °C and 36.87%–65.30%, respectively. The moisture content of fresh OFSP slices for both treated and untreated samples was found to be in the range of 291.55–302.24% (dry basis, db), which reduced to 25.25–35.25% (db) after drying. The drying time ranged between 11 and 13 hours. The page model was found to be the best model for untreated samples, with R^2 of 0.9948, RMSE of 0.0151, and χ^2 of 0.0097, while the logarithmic model best described the drying behaviour of all the pretreated samples because it had the highest values of R^2 and the lowest values of RMSE and χ^2. Lemon juice-pretreated samples had the best quality parameters (vitamin A retention and rehydration ratio). A maximum rehydration ratio of 1.6765 was obtained for samples pretreated with lemon juice, and a minimum rehydration ratio of 1.1390 was obtained from HWB-pretreted samples. The results, therefore, indicate that lemon juice can be used as a pretreatment for thin-layer drying of OFSP slices. Pretreatments help minimise postharvest losses associated with OFSP, thus contributing to solving food and nutrition insecurity challenges.

Keywords: Orange-fleshed sweet potatoes, bio-fortified, beta-carotene, pretreatments

1.0 Introduction

Orange-fleshed sweet potato (*Ipomoea batatas* L.) is a form of bio-fortified sweet potato with a high beta-carotene content that, upon consumption, is transformed into vitamin A, providing

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extra nutritional benefits to the body (Kurabachew, 2015). Malnutrition and vitamin A deficiency (VAD) are common in developing countries, where they affect about 44% of African preschool children, preventing them from growing and developing healthily (Oyunga et al., 2016). VAD affects 37% of Kenyan children and 39% of Kenyan mothers (particularly pregnant women) (Sahile et al., 2020). In order to prevent VAD, increasing vitamin A intake through the production of vitamin A-rich foods can have a significant effect (Neela & Fanta, 2019).

In Kenya, sweet potatoes have become a vital staple crop, particularly in the Western region, with an annual production of approximately 0.771 million metric tonnes (FAO, 2021). However, a significant challenge in the postharvest phase is the substantial loss of these nutritious tubers, which account for roughly 40–50% of the total production. To combat this issue, drying has long been employed as a prevalent method of food preservation, extending the shelf life of products and enabling their sale during off-season periods (Kiaya, 2014). Traditionally, Kenya has relied on open-sun drying, primarily due to its cost-effectiveness. Nevertheless, this method has inherent drawbacks affecting product quality, including prolonged drying times, exposure to dust, contaminants, and bacteria, and its labour-intensive nature. Additionally, open-sun drying becomes impractical during wet seasons. Solar drying has emerged as a viable alternative for farmers in developing nations in response to these challenges. Solar dryers can generate elevated air temperatures and maintain low relative humidity, creating optimal conditions for effective crop drying (Basunia & Abe, 2001).

Pre-drying treatment is an important operation commonly employed before drying to increase the drying rate and maintain the product's quality. Every crop has its own optimum conditions for pretreatment when drying. Different studies show that pretreating sweet potatoes with ascorbic acid, citric acid, sodium chloride, and calcium chloride can improve the quality maintenance of sweet potatoes during drying (Oke & Workneh, 2013).

Postharvest loss is a significant drawback in the agricultural sector. Agricultural products with high moisture content spoil faster if not preserved (dried) well. Different drying methods have been used to dry root tubers, such as cassava and potatoes. Some of the drying methods include sun drying and solar drying. Although drying with conventional air is the most common method, the drying time, due to low moisture removal rates from fruits and vegetables and, thus, low energy efficiency, is one of the most important disadvantages of this method (Salengke & Sastry, 2005). At the same time, it can adversely affect the quality parameters of the final product, such as colour, texture, and rehydration ability. Therefore, it is essential to find alternatives to increase the moisture removal rate, reduce energy consumption, and preserve the quality of the product during the drying process. Different pretreatment methods have been developed for agricultural product drying; these include: lemon juice, salt solution, honey dip, ascorbic acid, sulfuring, osmotic pretreatment, and blanching. If no pretreatment is done, the produce will continue to darken after drying, causing quality deterioration (Bhat et al., 2017). Assessment of different pretreatment methods has been carried out for various agricultural produce such as banana slices (Abano & Sam-Amoah, 2011), red pepper (Incedayi, 2020), and mango slices (Osunde, 2017), among others. The aim of the study was to evaluate the effects of pretreatments on thin-layer drying kinetics, vitamin A retention, and rehydration of orange-fleshed sweet potato slices.

2.0 Materials and methods

2.1 Study area

This research was carried out at the Jomo Kenyatta University of Agriculture and Technology (JKUAT) main campus in the Agricultural and Biosystems Engineering Department (ABED). JKUAT is located in Juja, Kiambu County, Kenya (37.05°E, 1.19°S latitude, and an altitude of 1550 m above sea level). The mean annual temperature of Juja is 18.8 °C, with mean annual maximum and minimum temperatures of 26.1 °C and 13.6 °C, respectively. The average annual rainfall is 1024 mm (Baloïtcha et al., 2022). The region experiences a bimodal rainfall pattern with cold, rainy seasons between April and August and October and December each year, with the rest of the period being dry and hot seasons (Watako et al., 2001).

2.2 Experimental solar dryer

The solar dryer that was used in this study was locally assembled as shown in Figure 1. The dryer consists of the main structure with a door and a concrete base. It is entirely covered with polyvinylchloride (PVC) material. The dryer is 4 m long, 2.05 m wide and 1.6 m high, and the door measures 1.6 m by 0.75 m. the centre part of the dryer is 2.1 m high. It is a gothic or gable roof type and covered with a 200-micron polythene cover material (Ndirangu et al., 2022). Solar energy was used during hot and sunny days.

Figure 1: Experimental solar dryer.

2.3 Sample acquisition and preparation

OFSP was purchased from a certified farmer in Juja, Kiambu County, Kenya. A random sampling method was used to pick 5 kilogrammes of OFSP tubers, which was a representative sample. The samples were obtained from a single farm and then homogenized. The OFSP was handled with the utmost care to prevent physical damage; they were also examined to determine any microbial attack upon arrival. Healthy OFSPs were washed in clean water to eliminate any dirt.

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A paper towel was used to dry water from the surface of the tubers. Using a clean kitchen knife, the samples were peeled by hand. After that, the peeled slices were sliced to 3mm (optimal) thickness. The control sample for the study was not pretreated. The other samples were pre-treated by salting, hot water blanching, and lemon juice. The salt solution was at a 10% concentration for 10 minutes (Deng et al., 2019). For the blanching method, the water bath was at 90 °C for 10 minutes (Chhe et al., 2018). The slices dipped in the lemon juice were left for 10 minutes also (Deng et al., 2019). These pre-treatment methods are necessary to reduce enzymatic browning and microbiological growth (Jayaraman & Gupta, 2020). These samples were immediately loaded on the drying trays in a thin layer. Figure 2 shows a flow chart from data collection to data analysis. Figure 3 shows the OFSP sample slices in a solar dryer.

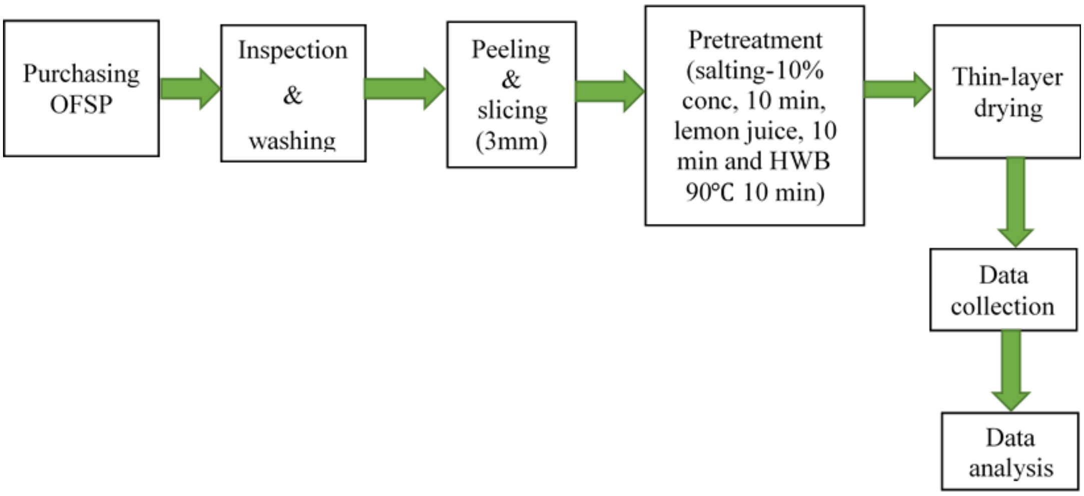

Figure 2: Flow chart for material acquisition to data analysis.

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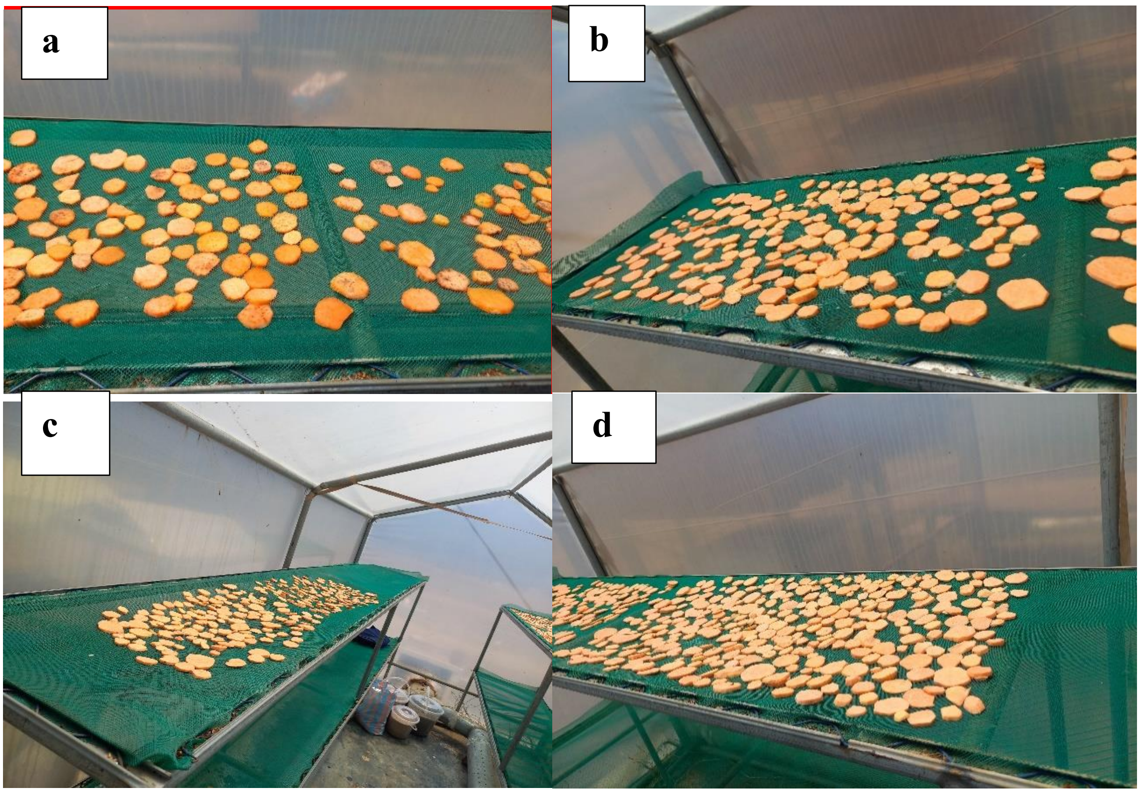

Figure 3: Fresh OFSP slice samples: (a) HWB, (b) Lemon juice, (c) Salting, and (d) Control.

2.4 Determining the thin layer drying parameters of pre-treated OFSP slices

The initial moisture content of the OFSP slices was determined using the oven dry method (AOAC, 2023). Data collection, the weighing of samples, and the recording of other parameters (temperature, relative humidity (RH), and solar radiation) were done at a 1-hour interval. Temperature and RH were measured using an SSN-22 USB temperature and humidity sensor. Solar radiation was measured using a digital handheld pyranometer. All the measurements were conducted with three replications for each parameter considered in the study. The final moisture content of the samples was determined by the oven drying method, and the value obtained was the equilibrium moisture content of the samples (at the drying air condition).

2.5 Modelling the thin layer drying kinetics of pre-treated OFSP slices in a solar dryer

Based on the theory of thin layer drying, commonly used mathematical models (Page, Logarithmic, Modified Page, and Henderson and Pabis) were used to plot graphs of moisture content against drying time. The drying rates were taken to be approximately proportional to the difference in moisture content between the dried OFSP slices and the equilibrium moisture content at the drying air state. Absolute moisture (M) is defined as the ratio of moisture content to dry matter, and it was determined for each of the experimental data. The equations, which express the moisture ratio (MR) as a function of time, were used to fit the experimental drying curves of the pretreated OFSP slices. Table 1 shows the mathematical models (Equations 1-4) that were used.

Table 1: Commonly used mathematical models

Model name	Model	Equation number	Reference
Page	$MR = \exp(-kt^{n})$	(1)	(Pathak et al., 1991)
Modified page	$MR = \exp[(-kt)^{n}]$	(2)	(Yaldiz et., 2001)
Logarithmic	$MR = a\exp(-kt) + b$	(3)	(Doymaz, 2010)
Henderson and Pabis	$MR = a\exp(-kt)$	(4)	(Pal & Chakraverty,1997)

*****a, b, n = empirical model coefficients, k= drying constant obtained from experimental data, and t = time

2.6 Effects of pre-treatment methods on vitamin A and rehydration of dried OFSP slices

Vitamin A concentration was determined using the partition chromatography method. The experimental procedure followed the AOAC standards (Thompson et al., 2010). 2 g of OFSP sample slices were weighed in a beaker, then transferred to a motor where 25 ml of cold acetone and sand were added. The slices were ground to extract the colour until no more colour remained in the sample, resulting in a white residue. Subsequently, the extract was transferred to a separating funnel, and 25 ml of petroleum ether was introduced. After washing off the acetone with distilled water, a 25-ml beta-carotene petroleum ether extract was obtained, passing through a bed of anhydrous sodium sulfate. The absorbance was read using a UV-VIS spectrophotometer set at 440 nm wavelength.

To determine the rehydration ratio, a 300-ml beaker containing 200 ml of boiled distilled water was used to soak the dried slices. The samples were rehydrated for five minutes. Then filter paper was used to dry the water off the sample, and the rehydrated mass was determined. Equation 5 was used to calculate the rehydration ratio, where Re is the rehydration ratio, W_1 is the weight of the dried sample (g), and W_2 is the weight of the drained sample (g).

$$\mathrm{Re} = \frac{W_2}{W_1} \tag{5}$$

2.7 Data analysis

The moisture content data obtained was used to establish the relationships between moisture content, drying rate, moisture ratio, relative humidity, and temperature with drying time. The moisture content dry basis (MC_{db}) at drying time t (minutes) was determined using Equation 6, where is the initial weight of the sample before drying (g) and is the weight of the sample at time t during drying (g).

$$MC_{db} = \left(\frac{W_w - W_d}{W_d}\right) \times 100 \tag{6}$$

The drying rate of OFSP was calculated based on the weight of water removed per unit time per unit weight of dry matter, expressed in units of (Sawhney et al., 1999). The overall drying rate was computed using Equation 7. In the equation, is the drying rate, is the change in mass (g), is the change in time, t is the total drying time, is the initial sample mass (g), and is the final dried sample mass (g).

$$R_d = \frac{\delta_m}{\delta_t} = \frac{m_i - m_f}{t} \qquad (7)$$

For a drying process in which the absence of a constant rate is observed, the drying rate is limited by the diffusion of moisture from the inside to the surface layer, represented by Fick's Law of Diffusion (Van et al., 2005). To apply Fick's Law, the food product is usually assumed to be uni-dimensional, have uniform initial moisture content, and have internal moisture movement as its main resistance to moisture transfer.

For mathematical modelling, the equations representing the models were tested to select the best model for describing the drying curve equation of OFSP slices during drying. The moisture ratio of OFSP slices during drying was calculated using Equation 8. In the equation, MR is the moisture ratio (dimensionless), M is the moisture content at time, t (%), is the initial moisture content (%), and is the equilibrium moisture content (%).

$$MR = \left(\frac{M - M_e}{M_o - M_e}\right) \qquad (8)$$

Non-linear Regression was performed using the coefficient of determination (R^2) to select the best equation to account for the variation in the drying curves of the dried sample. The Chi-square (χ^2), the mean square of the deviations between the experimental and estimated values for the models, was used to determine the goodness of fit. The lower the values of χ2 and the higher the values of R^2 indicates the better the fit of the model. χ^2, RMSE, and R^2 were calculated using Equations 9, 10, and 11, respectively. In the equations, $MR_{exp,i}$ is the experimental moisture ratio at observation i, $MR_{pre,i}$ is the predicted moisture ratio at this observation i, N is the number of observations, and n is the number of constants in the drying model.

$$X^2 = \frac{\sum_{i=1}^{N}\left(MR_{exp,i} - MR_{pre,i}\right)^2}{N-n} \qquad (9)$$

$$RMSE = \left(\frac{1}{N}\sum_{i=1}^{N}(MR_{pre,i} - MR_{exp,i})^2\right)^{1/2} \qquad (10)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\left(MR_{exp,i} - MR_{pre,\ i}\right)^2}{\left(MR_{exp} - MR_{exp,i}\right)^2} \qquad (11)$$

All measurements were conducted with three replications for each parameter considered in the study. For data analysis, the data was presented as means and deviations. The data were presented graphically as well as in tabular form. An analysis of variance (ANOVA) was also performed to ascertain whether or not the use of different pretreatments had any significant effect on the quality of OFSP slices.

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3.0 Results and discussion

3.1 Determination of thin-layer drying characteristics of pre-treated OFSP slices in a solar dryer

3.1.1 Temperature and RH

The variations of the drying conditions (temperature, relative humidity, and solar radiation) in a solar dryer are as shown in Figure 4. The temperatures inside the dryer ranged from 26.93 °C to 44.53 °C. Also, the maximum and minimum values of relative humidity inside the dryer were 65.30 and 36.87%, respectively. From the figure, it can be seen that the relative humidity is inversely proportional to the temperature. The variations in temperature and relative humidity were the result of shading from nearby trees and the time of day. It was also observed that an increase in solar radiation resulted in an increase in the air temperature and vice versa.

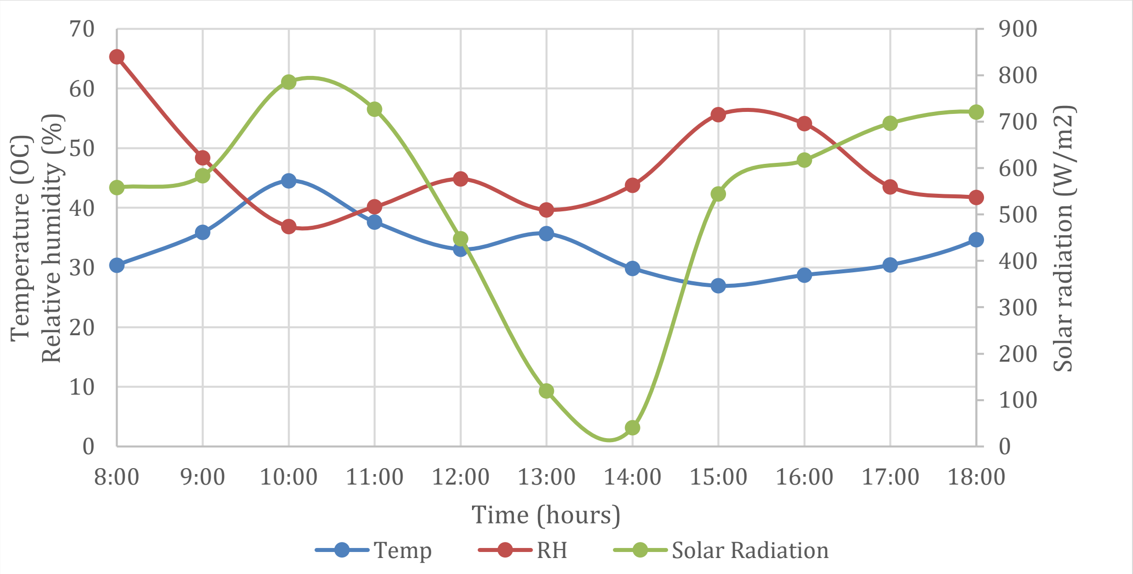

Figure 4: Variation of temperature, relative humidity and solar radiation with time.

3.1.2 Moisture content

Initial moisture content for the untreated and pre-treated OFSP samples was found to range between 291.55 and 302.24% dry basis (db), which was later reduced to 25.25–35.25% db. The time taken for the HWB, salting, lemon juice, and control samples to reach equilibrium moisture content was 13, 11, 11, and 12 hours, respectively. Comparing all the samples, HWB samples were found to take the longest time to reach equilibrium moisture content. This is because when the samples are put in hot water, they tend to cook, and this leads to the development of a gummy outer layer, which tends to harden and prevent water removal from the samples as the drying time increases. The shortest drying time was observed for samples pre-treated with salt and lemon juice. This is because of the osmotic dehydration. Both salt and lemon juice contain compounds that act as osmotic agents. When sweet potato samples are pre-treated with salt or lemon juice, the high osmotic pressure created by these substances draws moisture out of the sweet potato cells more effectively, accelerating the drying process (Rahman, 2020). Figure 5 shows the drying curves for the control and pre-treated samples. For all the samples, it can be observed that the moisture content decreased with an increase in drying time. In addition, at the beginning of drying, the moisture content dropped drastically and decreased as the drying time increased. Similar results were observed by Doymaz (2011) during the thin-layer drying of OFSP slices. This could be explained by increasing resistance to moisture diffusion inside the material due to the toughening of the outer layers of the product (Darvishi et al., 2012).

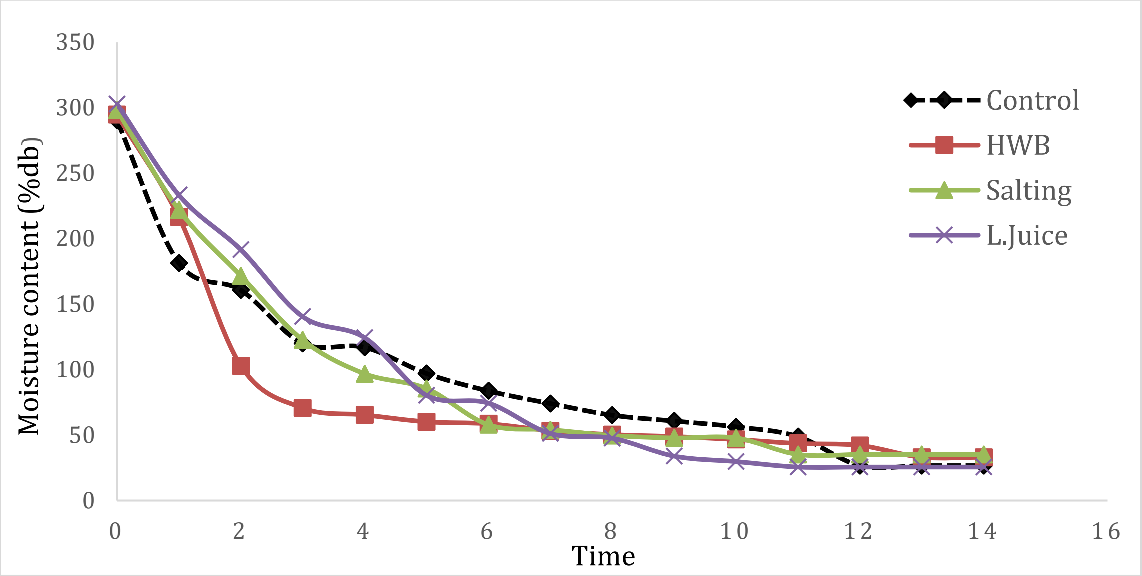

Figure 5: Drying curves for pre-treated OFSP slices dried in a solar dryer.

3.1.3 The drying rate

The drying rate of the OFSP slices was calculated and plotted against drying time, as shown in Figure 6. The drying rates were higher at the beginning of the drying process and gradually decreased as the drying process progressed for all the samples, which confirmed the findings by Ghanem et al. (2020). This was because more radiation energy was initially absorbed by the water at the product surface, resulting in faster drying. The drying rate of OFSP slices in the solar dryer was observed to vary with the time of day, due to varying environmental conditions and other factors such as shading from nearby trees. This variation was also observed by Gasa et al. (2022). As the drying rate increased, the amount of moisture that was removed from the product increased. The high drying rates caused an increase in the moisture migration and evaporation rate from the surface of the slices (Mugodo & Workneh, 2021). For all the samples, the entire drying process occurred only in the falling rate period because diffusion was a dominant physical mechanism governing moisture movement in the samples (Koua et al., 2009).

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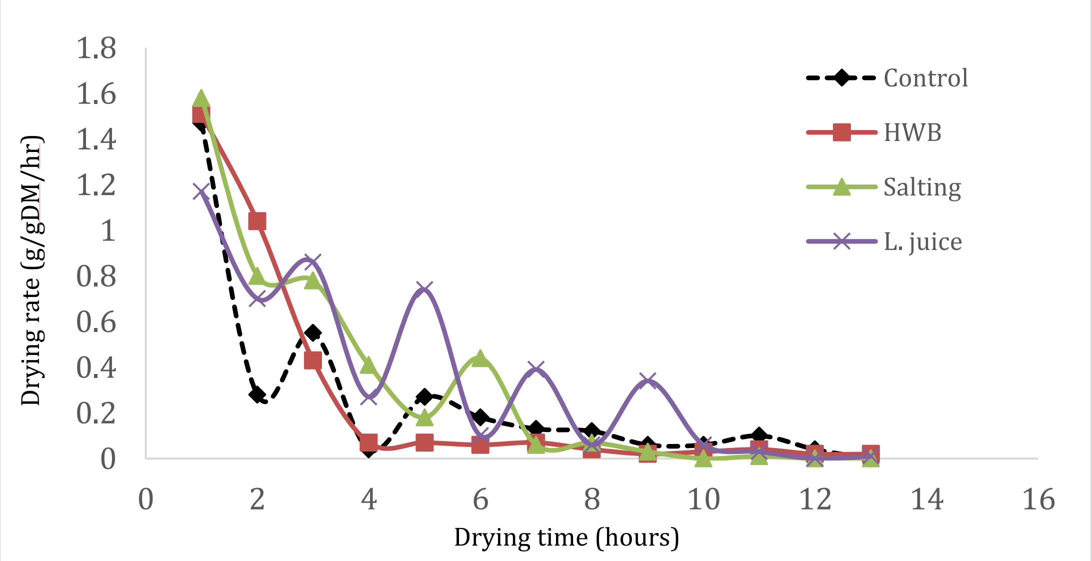

Figure 6: A plot of drying rate of OFSP slices against drying time.

3.2 Modelling of thin-layer drying kinetics of pre-treated OFSP slices in a solar dryer

The experimental results of moisture variation with drying time were fitted to four different drying models known in the literature, as presented in Table 1. By using Microsoft Excel, the parameters of the different models were determined. The model that provided the highest R^2 and the lowest values of RMSE and χ^2 was selected. The values of R^2, RMSE, and χ^2 obtained from the different mathematical models are summarised in Table 2 for the control sample and the three pre-treated samples. For the control sample, the R^2 value for the Page model was found to be the highest with a value of 0.9948 and the lowest RMSE and χ^2 values of 0.0151 and 0.009736, respectively. Hence, the Page model was proposed to be the best model for describing the drying behaviour of OFSP slices without pre-treatments. The high R^2 value indicated that the Page model accurately predicted how OFSP slices lost moisture during the drying process; hence, engineers can use this model to design and optimise drying processes more precisely, ensuring minimal wastage of energy and resources. The low RMSE and χ2 suggest that the Page model's predictions are closely aligned with the actual drying behaviour of untreated OFSP slices. This is valuable for quality control purposes. The results were in agreement with other literature studies on the drying of various agricultural products, such as banana slices (Ceylan et al., 2007), amaranth (Ronoh et al., 2009), and jackfruit slices (Ronoh et al., 2020). For all pre-treated samples, the R^2 values for the logarithmic model were found to be the highest, with the lowest values of RMSE and χ^2. For HWB, the values of R^2, RMSE, and χ^2 were 0.9765, 0.0355, and 0.041949, respectively. For salting, the values for R^2, RMSE, and χ^2 were 0.9972, 0.0124, and 0.00819, respectively. Finally, for lemon juice pre-treatment, the values for R^2, RMSE, and χ^2 were 0.9954, 0.0170, and 0.01464, respectively. Hence, the logarithmic model was proposed to be the best model for describing the drying behaviour of OFSP slices pre-treated with hot water, salting, and lemon juice. Similar results for the logarithmic model have been reported during thin layer drying studies of stone apple slices (Rayaguru & Routray, 2012).

A comparison of the predicted and experimental moisture ratios of control, HWB, salting, and lemon juice is presented in Figures 7–10. It can be clearly seen from Figure 7 that the Page model prediction was closer to the experimental moisture ratios compared to the other three models. For Figures 8–10, the logarithmic model prediction was close to the experimental moisture ratios compared to the other three models. This was further explained by the accuracy (highest R^2, lowest RMSE, and χ^2 values) in terms of predicting the thin layer drying characteristics of OFSP slices.

Table 2: Model constant parameters and goodness of fit for thin layer drying of OFSP slices

Sample	Model	Model constants	R^2	RMSE	χ^2
Control	Page	k = 0.4134 n = 0.5205	0.9948	0.0151	0.009736
	Modified Page	k = 0.4920 n = 0.3444	0.8025	0.0928	0.530459
	Logarithmic	a = 0.7209 c = 0.2284 k = 0.3483	0.9773	0.0341	0.027637
	Henderson & Pabis	a = 0.8233 k = 0.1314	0.8917	0.0688	0.197832
HWB	Page	k=0.5721 n=0.4961	0.9220	0.0647	0.176548
	Modified Page	k=0.3318 n=0.8296	0.7515.	0.1156	3.386593
	Logarithmic	a=0.8454 c=0.6043 k=0.1834	0.9765	0.0355	0.041949
	Henderson & Pabis	a=0.8522 k=0.2180	0.7834	0.1079	1.436358
Salting	Page	k=0.4359 n=0.5969	0.9722	0.0390	0.10762
	Modified Page	k=0.7255 n=0.3109	0.8713	0.0838	1.29205
	Logarithmic	a=0.8254 c=0.1730 k=0.4127	0.9972	0.0124	0.00819
	Henderson & Pabis	a=0.8795 k=0.1916	0.8976	0.0748	0.69734
Lemon juice	Page	k=0.2583 n=0.7968	0.9871	0.0285	0.05982
	Modified Page	k=0.3782 n=0.4728	0.9674	0.0454	0.23533
	Logarithmic	a=0.8704 c=0.1330 k=0.2573	0.9954	0.0170	0.01464
	Henderson & Pabis	a=0.9470 k=0.1678	0.9727	0.0415	0.17281

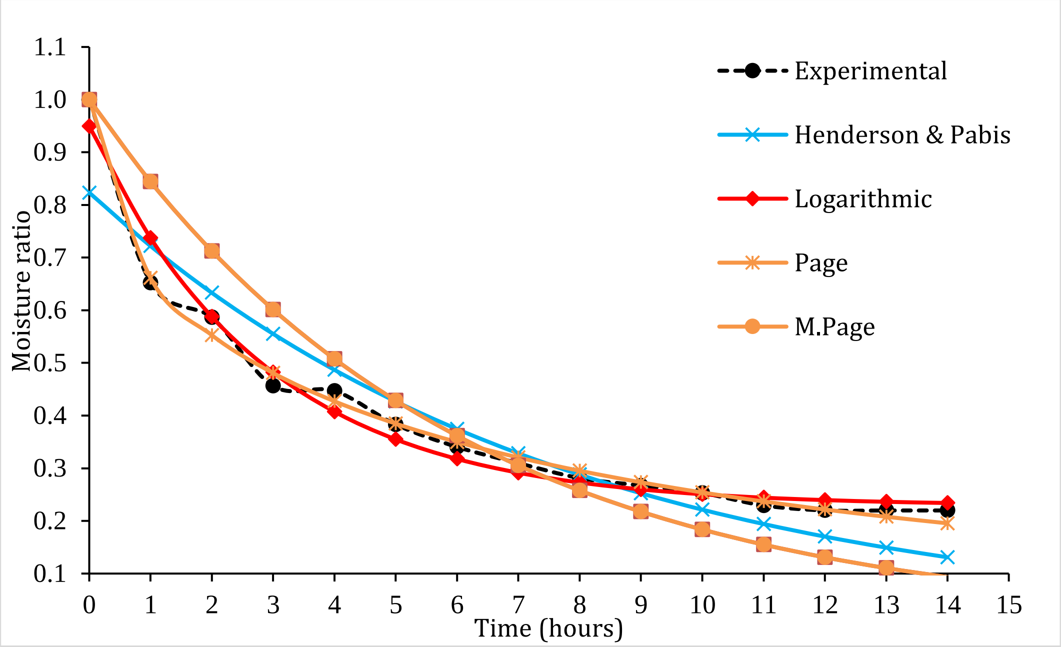

Figure 7: Comparison of predicted and experimental moisture ratios for control.

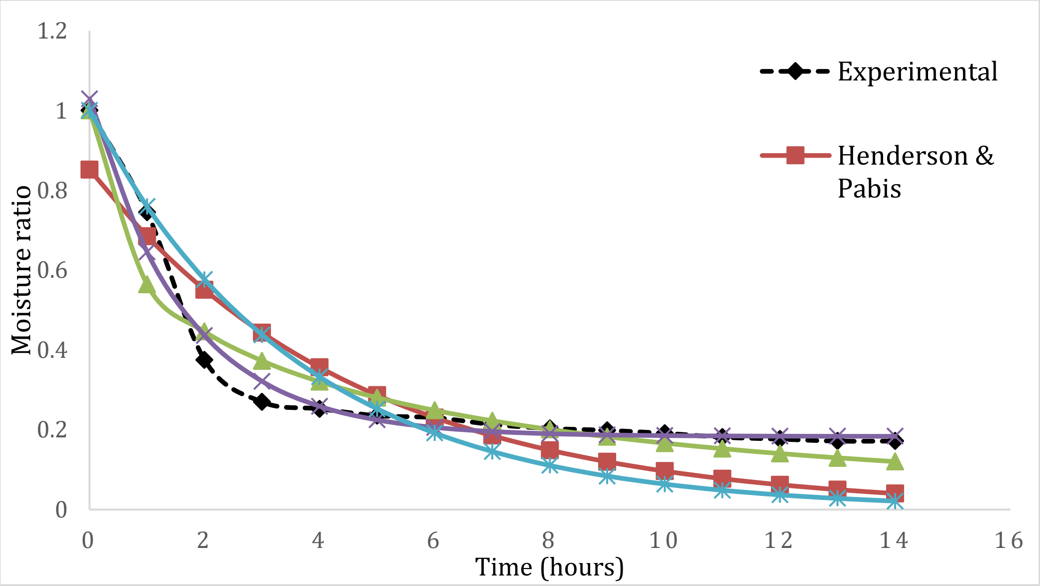

Figure 8: Comparison of predicted and experimental moisture ratios for HWB samples.

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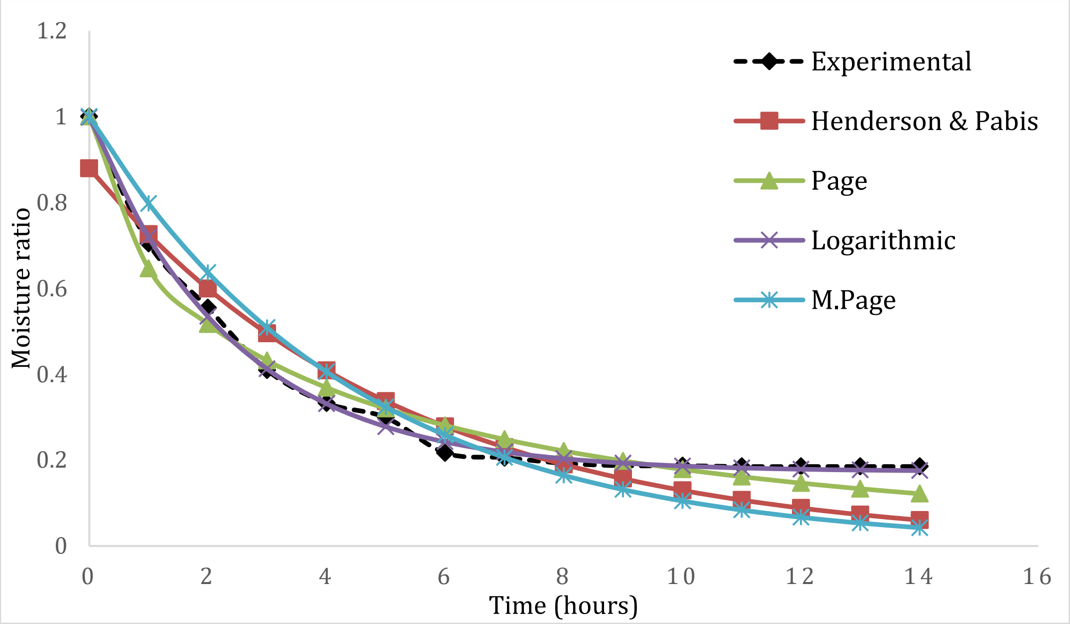

Figure 9: Comparison of predicted and experimental moisture ratios for salting samples.

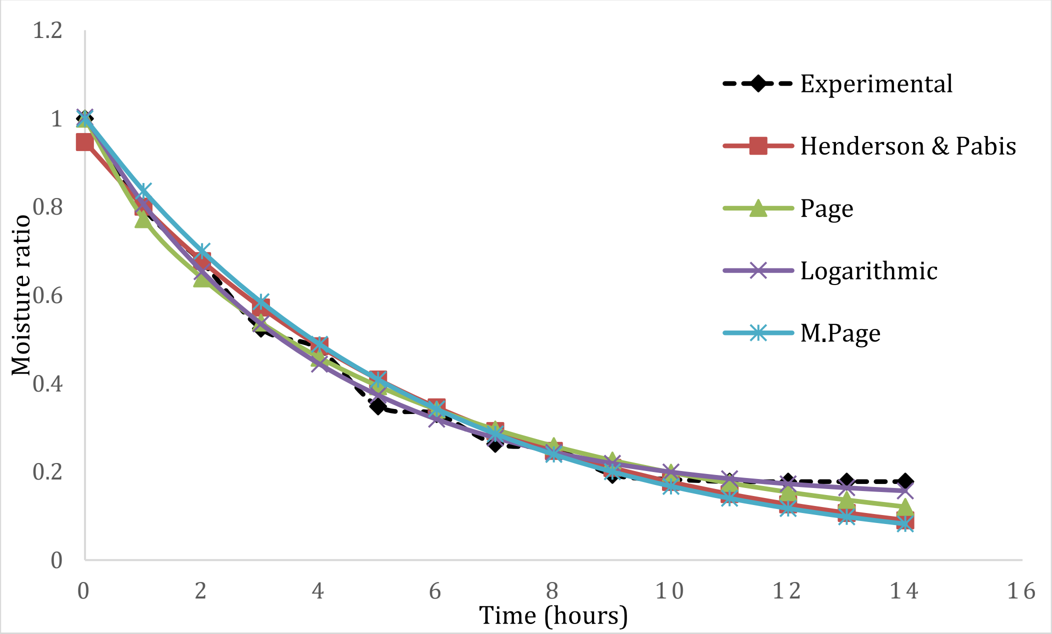

Figure 10: Comparison of predicted and experimental moisture ratios for lemon juice samples.

3.3 Evaluation of the effect of pre-treatment methods on the quality attributes (vitamin A retention, and rehydration) of dried OFSP slices

3.3.1 Vitamin A

Figure 11 shows a graph of the vitamin A concentration of OFSP slices against time. At the end of the drying period, salting had the highest beta-carotene content, with a concentration of 708 ppm. The beta-carotene concentration of lemon juice closely followed at 687 ppm. This is because salt stabilises beta-carotene, inhibiting chemical reactions that lead to the degradation of beta-carotene, such as oxidation. This helps maintain a higher beta-carotene concentration in the salt-treated samples (Bechoff et al., 2011). The control had a beta-carotene concentration of 630 ppm, and hot water blanching had the lowest concentration of 565 ppm. Analysis of variance for vitamin A concentration at the 5% level of significance yielded the following results: *p*-value, 0.9369; $F_{critical}$, 2.8165; $F_{compound}$, 0.1378. These results show that there was no significant difference ($p > 0.05$) in vitamin A concentration between the OFSP slices.

Hot water blanching destroyed the beta-carotene content due to heating-induced changes (Guiamba & Svanberg, 2016). Overall, it was seen that drying the blanched slices was difficult since the starch gelatinization rendered the samples sticky. It acted like incomplete cooking that interfered with the beta-carotene content. Similar results for HWB have been reported by Devi et al. (2015) during the preparation of value-added products through preservation.

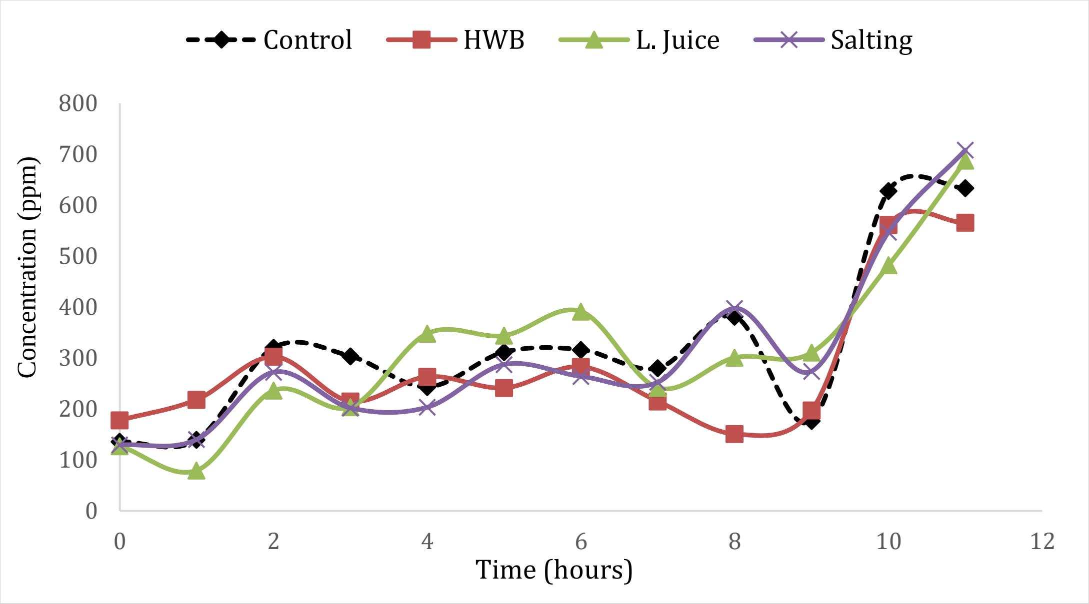

Figure 11: Variation of Vitamin A concentration as a function of time.

3.3.2 Rehydration ratio

The rehydration ratios for control, HWB, salting, and lemon juice were 1.50761, 1.13904, 1.57868, and 1.67647, respectively. A high rehydration ratio means the dried product has good quality because the pores allow water to re-enter the cells. Lemon juice-pretreated OFSP slices had the highest value of rehydration ratio compared to the other pre-treated samples, showing that they had better quality than the other samples. This is because pretreatments involving acid solutions or natural juices often soften the cell structure, increase porosity, and promote better water absorption during rehydration (Vásquez et al., 2013). These results were similar to those of Gasa (2019) on the drying of sweet potato tubers using a solar venturi ventilated and hot air dryer.

4.0 Conclusions

In conclusion, the study on the effects of pretreatments on thin-layer drying kinetics, vitamin A, and rehydration of OFSP slices has shed light on the efficiency of various pretreatment methods and drying models. This research underscores the significance of pretreatments on drying with lemon juice and salting, increasing the drying rate compared to HWB and untreated samples. The Page and Logarithmic models were the best models for describing the drying behaviour of untreated and pretreated samples, respectively. Furthermore, this study shows that a high concentration of beta-carotene was found in all samples, with salt having the highest levels. Finally, the rehydration ratios (Re) emphasize the quality of the dried products, with lemon juice pretreatment yielding the highest rehydration ratio. Collectively, these findings contribute to a better understanding of the drying process of OFSP and offer valuable insights for optimizing its preservation and quality.

Considering the significant advantages of lemon juice in terms of reducing drying time and improving quality parameters such as vitamin A retention and Re, it is recommended that farmers embrace the use of lemon juice as the preferred pretreatment method for thin layer drying of OFSP slices. Also, to enhance drying efficiency, it is advisable to augment the air circulation velocity within the solar dryer, as this will not only expedite the drying process but also contribute to lowering the RH within the dryer. Finally, since this study revealed the issue of OFSP slice cooking when HWB is employed, future research endeavours should explore the potential benefits of steam blanching as an alternative pretreatment method.

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5.1 General acknowledgement

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5.2 Declaration of interest

None. The presented work was partly in fulfillment of the requirements of obtaining a degree in BSc Agricultural and Biosystems Engineering for the first and second authors.

5.3 Conflict of interest

The authors declare no conflict of interest regarding the publication of this paper.

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