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Drying parameters of wild lettuce (*Lactuca taraxaxifolia* L) affected by different drying methods

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ABSTRACT

This study focused on the effect of drying method on drying properties of wild lettuce leaves. The fresh wild lettuce was washed thoroughly to remove extraneous parts and subjected to pretreatments by dipping 200 g of vegetable samples into the water (1.5w/v) solution with 0.3% sodium metabisulphite held at room temperature. The pre-treated and untreated leaves were weighed and loaded in stainless steel tray and subjected to drying under cabinet dryer, open-sun drying and solar dryer. The wild lettuce drying curve exhibits a gentle downward curve, i.e. a high moisture loss at the early period of drying for all the drying methods used. The effective moisture diffusivity and activation energy were determined. The effective moisture diffusivity increased with the increase in temperature of drying. This study showed that post harvest losses of wild letuce can be minimized through drying, using mechnical devices or open sun drying, which is one of the oldest preservation processes available to the mankind.

Introduction

The world's population is expected to grow to almost 10 billion by 2050, boosting the demand for agricultural products (FAO, 2017). Vegetables, including vitamins, minerals, phytochemicals, dietary fiber and antioxidants, are important part of the human diet, because of their nutritional properties and beneficial human health effects (Slavin and Lloyd, 2012). Spoilage and post harvest losses of plant products occurs all over the world due to various factors leading to significant wastage. These losses may be due to environmental factors such as pH, temperature and oxygen, as well as other factors such as some consumer attitudes (Alegbeleye et al., 2022). Postharvest loss reduction is of high importance in combatting hunger, raising income and improving food security for vulnerable people and also in improving agricultural productivity and linkages between farmers and markets (ACLF, 2022). The post harvest losses of biomaterials can be minimized through drying, which is one of the oldest preservation processes available to the mankind. In today's food market, dried foods play an important role in the food supply chain by lowering the water content in order to avoid or slow down food spoilage by microorganisms (Naseer et al., 2013). The chances that microbial spoilage agents will be established at any point along these stages depend on certain factors, such as surface morphology and topography, plant surface exudates, developmental stage and post-harvest handling (Kumar et al., 2018).

Lactuca taraxacifolia, also known as bitter, opium or African lettuce, is native to many areas of the world, including North America, Europe, Middle East and West Africa. It is currently a neglected indigenous

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leafy vegetable in Nigeria (Busari et al., 2016). The leaves can be eaten fresh as salad or cooked in soups and sauces (Sakpere et al., 2011). They are reportedly richer than many common vegetables in Nigeria like *Solanum aethiopicum, Talinum triangulare* (Yekeen et al., 2011) and contain more (almost double) beta carotene than *Telfairia occidentalis* (Adewale et al., 2013). The extracts of wild lettuce seeds, leaves and sap are added to a number of natural products to relieve a variety of health problems, such as pain, anxiety, respiratory problems, menstrual cramps, arthritis, cancer, insomnia, poor circulation, restlessness and urinary infections (Kubala, 2018; Bello et al., 2018). The composition of wild lettuce leaves per 100 g edible portion is: water 84.3 g, energy 44 kcal, protein 3.2 g, fat 0.8 g, carbohydrate 8.3 g, fibre 2.0 g, Ca 326 mg and P 58 mg (Eshemokha, 2019). The high content of crude fibre, protein, calcium, iron, potassium in wild kettuce makes it a potent nutritious food supplement which can improve the health status of its consumers (Schippers, 2000).

Wild lettuce leaves contain high moisture content which predisposes them to wilting and rapid spoilage (Busari et al., 2016), hence the need for drying to enlogate their shelf life. Major studies on wild lettuce leaves have focused on its composition (Busari et al., 2016) and antioxidant properties of its extract in food application (Arawande et al., 2012; Arawande and Ogunyemi, 2012), with a dearth of information on the effect of drying methods on some drying parameters of wild lettuce. Drying refers to the application of heat and mass transfer process that involves vaporization of water in the liquid state, mixing the vapour with the drying air and removing the vapour naturally or mechanically from biomaterials (Onifade and Jekayinfa, 2015; Onifade et al., 2016). Drying is a complex thermodynamic process involving heat and mass transfers (Keneni et al., 2019) and providing information on the properties of water and energy required in enthalpy and entropy, which characterize variations existing in the water-product system (Wellytton et al., 2019). Drying has been widely adopted as the best option to preserve wild lettuce vegetable during abundant harvesting in rural areas. It reduces product's water activity, inhibits microbial growth and degradation reactions and results in higher stability and longetivity. It also results in substantial volume reduction which facilitates transportation and storage (Marques, 2009).

Drying process should be in such a way that would apply minimum changes in products quantitative indexes, including physical aspects (such as dimensions and size, texture, shape, wrinkles and stiffness) and chemical changes (such as browning reactions, discoloration changes in vitamin, amino acid and oxidation of substance) (Ogunlade and Aremu, 2019; 2020). As a result of high moisture and short shelf life of wild lettuce leaves, there is a need to process and store them for longer periods to make them available all year round ,which is possible through adequate drying methods. Hence the need for this study.

Materials and methods

Sample collection and preparation

Fresh *Lactuca taraxacifolia* variety was harvested from a local farm at the Teaching and Research farm of Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Nigeria. It was washed thoroughly to remove extraneous parts. Sodium metabisulphite of analytical grade was obtained at food chemistry laboratory. It was measured and weighed using an electronic compact scale (SF 400A, 5000 g x 0.001 g). Cabinet and solar dryer were used at the food processing laboratory. It was cleaned properly before experimentation. Samples were further subjected to two (2) pretreatments and untreated wild lettuce leaves were used as control samples. Treatment was carried out by dipping 200 g of vegetable samples into water (1.5w/v) solution with 0.3% sodium metabisulphite held at room temperature for two minutes (Kaur et al., 2006).

Selection of drying methods

The pre-treated and untreated leaves were weighed and loaded in stainless steel tray and subjected to different drying conditions (cabinet dryer, open-sun and solar dryer). 200 g of the sample was used for all drying methods.

i. *Solar drying*: The stalk of the freshly harvested wild lettuce was removed and 200 g of the vegetable was weighed. The sample was spread on a stainless tray and dried using solar dryer. The reading was taken at every one hour interval until constant weight was obtained. Drying was carried out for at least 4 hours a day. The sample was placed inside the desiccator until the next day to prevent rehydration. The dried vegetable was packed and sealed in high density cellophane bag for further analyses.

ii. *Cabinet drying*: The samples were spread on a stainless tray and dried using a 50 kg cabinet dryer at 45, 50 and 55 °C. The sample was weighed every hour until constant weight was obtained.

iii. *Open-Sun drying:* The sample was spread on a tray and dried under the sun. They were weighed every hour until constant weight was obtained at a solar intensity of 4.95 kWh/m^2/day.

Drying parameters

The moisture content of the wild lettuce was calculated using Equation 1 (AOAC, 2005) standard method.

$$MC = \frac{Wi-Wd}{Wi}\ x\ 100\% \qquad (1)$$

where: MC is the moisture content (%wb), W_i is the initial mass of the sample before drying (g) and W_d is the mass of the sample at drying time t (min).

The moisture ratio during drying experiment was obtained by using Equation 2:

$$MR = \frac{M-Me}{Mi-Me} \qquad (2)$$

where: MR is the dimensionless moisture ratio, M, M_e and M_i is the moisture content (% wb) at any time t, equilibrium moisture content and initial moisture content, respectively.

However, the moisture ratio (MR) was simplified to M/M_i instead of $(M-M_e)/(M_i-M_e)$ because of the relative humidity of the drying air, which continuously fluctuated during solar drying processes (Menges and Ertekin, 2006). Hence, moisture ratio was calculated as:

$$MR = \frac{M}{Mi} \qquad (3)$$

where: M is the moisture content (% wb), at any time t and M_i is initial moisture content (%wb), respectively.

Drying rate (DR) of the sample during drying experiment was calculated using the Equation 4:

$$DR = \frac{m_t-m_{t-1}}{t} \qquad (4)$$

All parameters remain as defined.

Effective moisture diffusivity and activation energy

Effective moisture diffusivity (D_{eff}) was calculated by using Fick's second equation of diffusion, as reported by Usub et al. (2010) and Aremu et al. (2013), considering a constant moisture diffusivity, infinite slab geometry, and a uniform initial moisture distribution as presented in Equation 5:

$$MR = \frac{8}{\pi^2}\exp[-\frac{\pi^2 D_{Eff}}{4L^2}t] \qquad (5)$$

where: MR is the moisture ratio, D_{eff} (m^2s^{-1}) is the effective moisture diffusivity, L (m) is the sample thickness and t is the drying time (s).

Equation 5, which involved a series of exponents, can be simplified to Equation 6:

$$lnMR = \left[-\frac{\pi^2 D_{Eff}}{4L^2}t\right] + [\frac{ln8}{\pi^2}] \qquad (6)$$

The effective diffusivity (D_{eff}) at each temperature was obtained from the slope of the plot of ln (MR) against time for corresponding temperature data.
Activation energy was calculated by using an Arrhenius equation (Aghbashlo, 2008), given in Equation 7:

$$D_{Eff} = D_0 e^{-\frac{Ea}{Rg(T+273.15)}} \qquad (7)$$

where: D_o is the maximum diffusion co-efficient, Ea is the activation energy ($kJmol^{-1}$), T is temperature (°C) and Rg is the gas constant (8.3145 J/mol/K).

$$ln\ D_{Eff} = \left[-\frac{1}{R_g(T+273.15)}\right]E_a + lnD_0 \qquad (8)$$

In the same manner, the activation energy was obtained as the slope of the lnD_{eff} against half-life by using rate constant (k) as presented in Equation 9:

$$Halflife = \left[-\frac{1}{R_g(T+273.15)}\right] \qquad (9)$$

Results

Drying rate curve for wild lettuce

The drying curve was obtained as the plot of moisture content with respect to time (Figure 1), while the drying rate curve was obtained as the plot of drying rate with respect to average moisture content (Figure 2). Wild lettuce leaves took an average of 6 hrs to dry up in solar dryer, and an average of 8, 7 and 6 hrs in cabinet dryer at 45, 50 and 55 °C, respectively, while they took 8 hrs to dry up under the sun at an average temperature of 39 °C and average solar intensity of 4.95 $kWh/m^2/day$. The final moisture content for sample was obtained to be 27.8, 25.1, 24.6, 23 and 28.3 g water /g material for solar dryer, 45, 50 and 55 °C cabinet dryer and sun drying, respectively. The moisture diffusivity values, under different drying methods, are presented in Figure 3, while the D_{eff} values for the drying of wild lettuce are shown in Table 1.

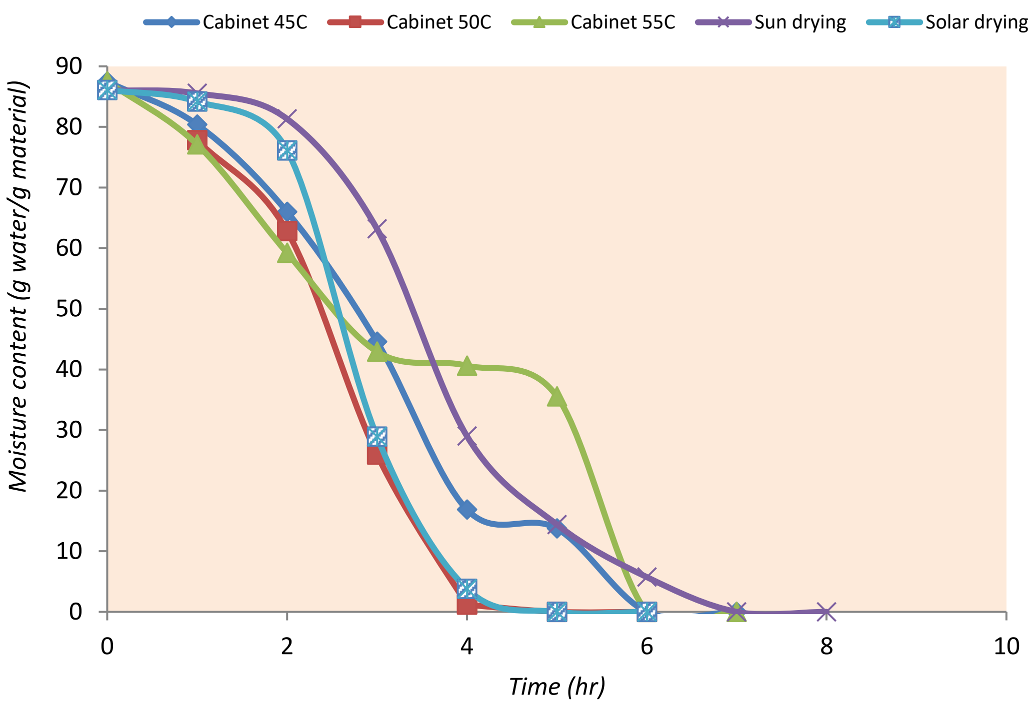

Figure 1. Drying curve for wild lettuce

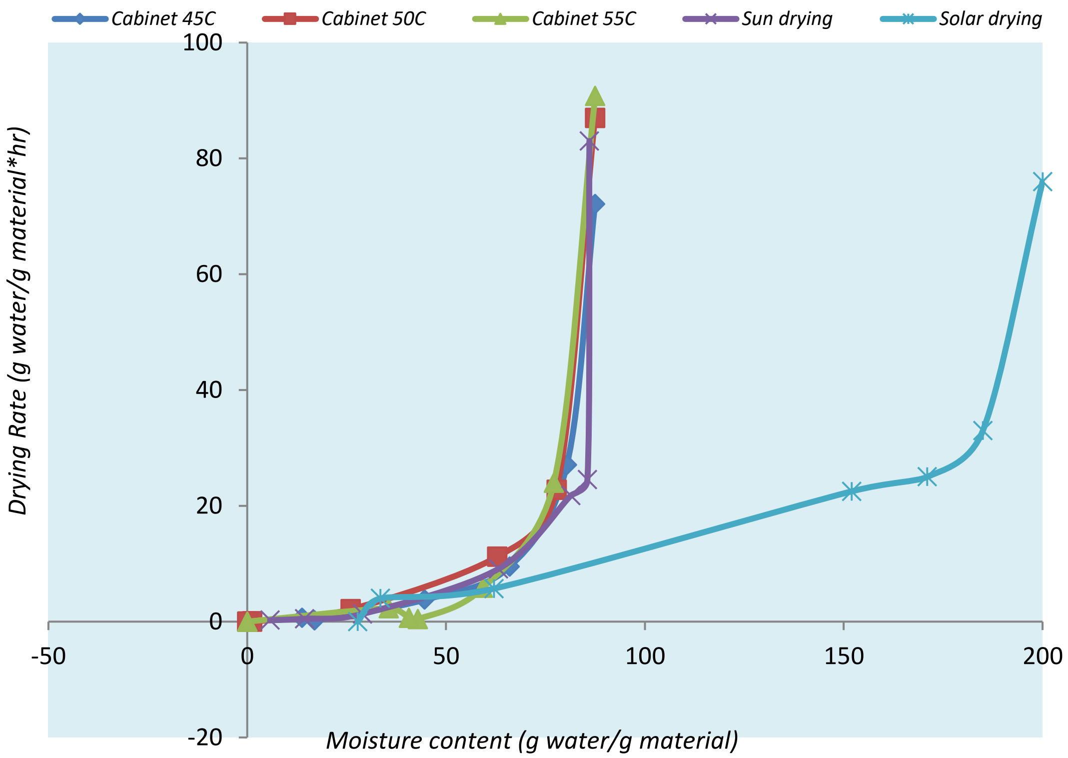

Figure 2. Drying rate curve for drying wild lettuce using different drying methods

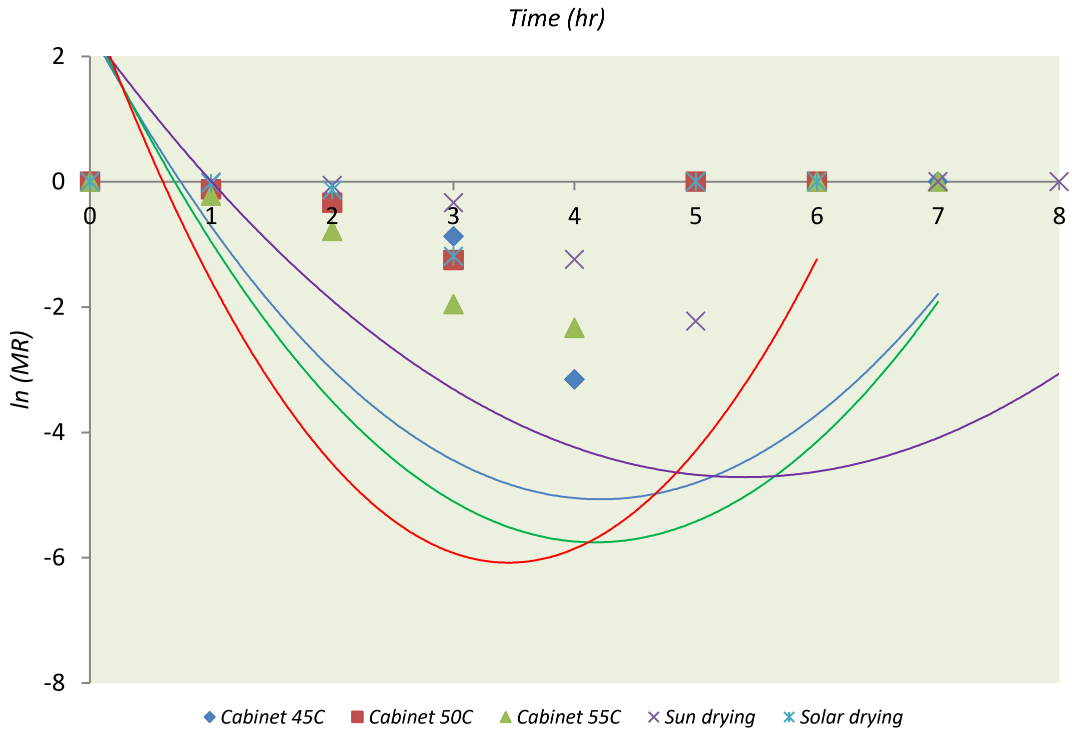

Figure 3. Estimation of moisture diffusivity for wild lettuce using different drying methods

Table 1. Effective moisture diffusivity (m^2/s) of the different drying processes of wild lettuce

Samples	Effective moisture diffusivity (m^2/s)
45 °C	$3.19x10^{-11}$
50 °C	$2.77\ x10^{-10}$
55 °C	$3.89x10^{-10}$
Sun drying	$1.69x10^{-10}$
Solar drying	$1.62x10^{-10}$

Discussion

Drying rate curve for wild lettuce

A gradual decrease in moisture content as drying time increases was observed as presented in Figure 1. The wild lettuce drying curve exhibits a gentle downward curve; a high moisture loss at the early period of drying for all the drying methods used (solar, cabinet and open-sun) was also observed. This is in line with similar leaves of *Piper aduncum* (Wellytton et al., 2019), blackberry (Elton et al., 2018), and drumstick (Premi et al., 2010). This may be due to the free water that tends to evaporate from the wild lettuce sample under the first approach of intense heat. The reduction in moisture content slowed down in the later drying periods, which implies that the free water evaporated leaving the bound water. This result is in harmony with the findings of Olajire (2018) for okra, Kabiru et al. (2013) for mango slices, and Islam et al. (2012) for green banana. Wild lettuce samples dried up at a faster rate under cabinet dryer than other drying methods used. This is because the drying temperatures for cabinet drying was higher than for other drying methods. This is similar to the drying of okra under cabinet, solar and open sun drying (Bhosale and Arya, 2004). The drying rate curves (Figure 2) shows that the drying rate was higher at the beginning of drying, when the moisture content of wild lettuce was the highest, while it decreased as drying progressed. This is due to the fact that free water evaporates,as drying progresses, while the remaining bound water is difficult to evaporate, which reduces the rate at which water evaporates from the surface of the wild lettuce. The drying rate also increased with the increase in drying air temperature, which is in agreement with cocoa beans (Jekayinfa, 2000; Ndukwu, 2009). This may, however, be due to the fact that higher air temperatures result in moisture migration, which increases the rate at which water is evaporated from the surface of the wild lettuce samples.

Effective moisture diffusivity (D_{eff}) and activation energy for wild lettuce

Diffusivity is used to indicate the flow of moisture in materials during drying. The falling rate period of drying moisture transfer is mainly by molecular diffusion (Rahman and Lamb, 1991; Madamba et al., 1996; Usub et al., 2010). The effective diffusivity (D_{eff}) of wild lettuce estimated by using the simplified mathematical Fick's second law of diffusion was developed for particles in a finite circular cylinder geometry, with the assumption of moisture migration being by diffusion and constant diffusion coefficients. Moisture diffusivity is a complex and system specific function. The effective moisture diffusivity of a food material characterizes its intrinsic mass transport properties of moisture, which include molecular diffusions of liquid and vapor, hydrodynamic flow and other possible mass transport mechanisms (Karathanos et al., 1990; El-Beltagy et al., 2007; Dhali and Datta, 2018). The effective moisture diffusivity of the wild lettuce under solar, cabinet drying (at at 45, 50 and 55 °C) and open sun drying were 1.62×10^{-10} (3.19×10^{-11} m^2/s, 2.77×10^{-10} m^2/s and 3.89×10^{-10} m^2/s) and 1.69×10^{-10} m^2/s, respectively, as presented in Table 1. These values fell within the normally expected range of Deff (10^{-11} to 10^{-9} m^2/s) for food materials (Babalis and Belessiotis, 2004; Madamba et al., 1996; McMinn and Magee, 1999). The Deff depended on the drying air temperature (Babalis and Belessiotis, 2004). It was observed that D_{eff} increased with an increase in temperature. This may be attributed to the fact that water diffusion, which is mainly due to mass transport mechanism from the first phase of drying, increases with an increase in drying temperature. This result is in line with Ojediran and Raji (2011), in the thin-layer drying characteristic of castor (*Ricinus Communis*) seed.

Conclusions

Advances in dehydration techniques and development of novel drying methods have in recent years enabled the preparation of a wide range of dehydrated products and convenience foods from fruits and vegetables, meeting the quality, stability and functional requirements, with economy.

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References

ACLF (2022): Post-harvest losses and strategies to reduce them. Action Contre La Faim. Available online at https://www.actioncontrelafaim.org/en/publication/post-harvest-losses-and-strategies-to-reduce-them/. Accessed 30th August, 2022. 12:11

Adewale A., Ayoade A. A., Alani E. A. (2013): Determination of vitamins in five selected West African green leafy vegetables, *Journal of American Science* 9, 40-43.

Aghbashlo, M. K., Arabhosseini, M. H. and Nazghelichi, T. (2008): Modelling the carrot thin-layer drying in a semi-industrial continuous bad dryer, *Journal of Food Science* 29(5), 528 - 538.

Alegbeleye, O., Odeyemi, O. A., Strateva, M., Stratev, D. (2022): Microbial spoilage of vegetables, fruits and cereals, *Applied Food Research* 2 (1), 100122. https://doi.org/10.1016/j.afres.2022.100122.

Arawande J. O., Komolafe E. A., Ijitona O. O. (2012): Antioxidative effect of wild lettuce (*Launaea taraxaciafolia*) on stability of refined soybean oil, *Journal of Agricultural Technology* 8, 2283-2295.

Arawande J., Ogunyemi O. (2012). Effect of Methanol and Water Extract of African Lettuce (Lactuca taraxacifolia) on Stability of Refined Palm Kernel Oil, *Nigerian Food Journal* 30, 1-7.

Aremu, A. K., Adedokun, A. J. and Abduganiyu, O. R. (2013): Effect of slice thickness and temperature on the drying kinetics of mango, *Agricultural Engineering Journal* 15 (1), 41 - 50.

Babalis, S. J. and Belessiotis, V. G. (2004). Influence of the drying conditions on the drying constants and moisture diffusivity during the thin layer drying of figs, *J Food Eng* 65, 449 – 458.

Bello, O. M., Abiodun, B. O. and Uduma, A. U. (2018): Launaea taraxacifolia; a Neglected Vegetable from Nigeria, its Antiinflammatory and Antioxidant

Activities, *ChemSearch Journal*, *African Journal online* 9 (1), 9 – 12.

Bhosale, S. S. and Arya, A. B. (2004): Effect of different modes of drying on moisture content and drying time of selected vegetable, *Indian Journal of Food Engineering* 63 (3), 349 – 359.

Busari, K. R., Oyeyinka, S. A., Akinoso, R., and Aworh, O. C. (2016): Nutritional and sensory properties of wild lettuce (Lactuca taraxacifolia) leaves as affected by sun drying alone or in combination with blanching, *Croatian Journal of Food Technology, Biotechnology and Nutrition* 11 (1-2), 28-35.

Dhali, K., and A. K. Datta (2018): Experimental analyses of drying characteristics of selected food samples, *Agricultural Engineering International: CIGR Journal* 20(4), 188–194.

El-Beltagy, A., Gamea, G. R. and Amer-Essa, A. H. (2007): Solar drying characteristics of strawberry, *J Food Eng* 78, 456 – 464.

Elton, A. S. M., André, L. D. G., Alexandre, A. G., Cesar, P. H. F., Valdiney, C. S. and Guilherme, C. O. (2018): Drying kinetics of blackberry leaves, *Revista Brasileira de Engenharia Agrícola e Ambiental* 22 (8), 570 – 576. https://doi.org/10.1590/1807-1929/agriambi.v22n8p570-576

Eshemokha, U. (2019): All you need to know about wild lettuce. Nigerian health Blog. https://nimedhealth.com.ng/ Retrieved 18th November, 2020. 9:47.

FAO. 2017. The future of food and agriculture – Trends and challenges. Rome. Available online at https://www.fao.org/3/i6583e/i6583e.pdf. Accessed 30th August, 2022. 11:48

Islam, M. S., Haque, M. A.and Islam, M. N. (2012). Effect of drying parameter on dehydration of green banana (*Musa sepientem*) and its use in potato (*Solanum tuberosum*) chips formulation, *Scientific Journal of Krishi Fundation* 10, 87 – 97.

Jekayinfa, S.O. (2000): A Study of Resistance to Airflow in Cocoa Beans Drying, *Journal of Science, Engineering and Technology* 8 (1), 3072 – 3082

Kabiru, A. A., Joshua A. A. and Raji, A. O. (2013): Effect of slice thickness and temperature on the drying kinetics of mango *(Mangifera indica*), *International Journal of Research and Review in Applied Sciences* 15, 41 – 50.

Karathanos, V. T., G. Villalobos, and D. G. Saravacor (1990): Comparison of two methods of estimation of the effective of the effective moisture diffusivity from drying dana, *Journal of Food Science* 55(1), 218–231.

Kaur, A. Kumar, S. Arora, K. and. Singh,G. B. (2006): Quality of dried coriander leaves as affected by pretreatments and method of drying, *Drying Technology* 223, 189 – 194.

Keneni, Y. G., Trine Hvoslef-Eideb, A. K., Marchetti, J. M. (2019): Mathematical modelling of the drying kinetics of Jatropha curcas L. seeds, *Industrial Crops & Products* 132 (2019), 12 – 20.

Kubala, Jillian (2018): Wild lettuce: Does it Provide Natural pain relief?. Nutrition: Healthline Media a Red Ventures Company. Available online at https://www.healthline.com/nutrition/wild-lettuce#other-benefits Accessed 17th November, 2020. 15:12.

Kumar, G. D., Ravi, S., Micallef, S. A., Brown, E. W. and D. Macarisin (2018): Aeolian contamination of fruits by enteric pathogens: An unexplored paradigm, *Current Opinion in Food Science* 19 (2018), 138-144. https://doi.org/10.1016/j.cofs.2017.12.003

Madamba, P. S., Driscoll, R. H. and Buckle, K. A. (1996): The thin-layer drying characteristics of garlic slices, *J Food Eng* 29, 75–97.

McMinn, W. A. M. and Magee, T. R. A. (1999): Principles, methods and applications of the convective drying of food stuffs, *Trans IChemE* 77(Part C), 175–193.

Menges, H.and Ertekin, (2006): Mathematical modelling of Thin; layers drying of Golden apples, *Journal of Food Engineering* 77(1), 119-125.

Naseer, A., Jagmohan, S., Harmeet, C., Prerna, G., Anisa, A., and Harleen, K. (2013): Different Drying Methods: Their Applications and Recent Advances, *Int. J. Food Nutr. Saf.* 4(1), 34-42.

Ndukwu, M. C. (2009): Effect of air temperature and drying air velocity on the drying rate and drying constant of coca beans, *Agricultural Engineering: CIGR EJournal* Manuscript 1091, (1), 23 – 30.

Ogunlade, C. A. and Aremu, A. K. (2019): Influence of Processing Conditions on Yield and Quality of Mechanically Expressed African Oil Bean (*Pentaclethra macrophylla* Benth) Kernels: A Response Surface Approach. Journal of Food Process Engineering, John Wiley. 42 (2), 1-9. https://doi.org/10.1111/jfpe.12967 and https://onlinelibrary.wiley.com/doi/pdf/10.1111/jfpe.12967

Ogunlade, C. A. and Aremu, A. K. (2020): Modeling and optimisation of oil recovery and throughput capacity in mechanically expressing oil from African oil bean (*Pentaclethra macrophylla* Benth) kernels, *Journal of Food Science and Technology*, *Springer Science*. 57, 4022 – 4031. https://doi.org/10.1007/s13197-020-04435-0. http://link.springer.com/article/10.1007/s13197-020-04435-0

Ojediran, J. O. and Raji, A. O. (2011): Thin-layer drying characteristic of castor (*Ricinus Communis*) seed, *Journal of Food Processing and Preservation* 35 (5), 647 – 655.

Olajire, A.S, Tunde Akintunde, T.Y and Ogunlakin, G.O (2018): Drying of kinetics and moisture Diffusivity study of okro, *Journal of Food Processing Technology* 9(9), 1-7.

Onifade, T. B. and Jekayinfa, S. O. (2015): Application of Response Surface Methodology for Energy Analysis of Thin Layer Drying of Physic Nut (Jatropha Curcas), *GSTF Journal on Agricultural Engineering (JAE)* 2 (1), 49 – 59.

Onifade, T.B., Taiwo, A. and Jekayinfa, S.O. (2016): Modification of a Locally Made Electric Crop Dryer, *Journal of Innovative and System Engineering* 7(2), 40-51

Premi, M., Sharma, H. K., Sarkar, B. C. and C. Singh (2010): Kinetics of drumstick leaves (Moringa oleifera) during convective drying, *African Journal of Plant Science* 4 (10), 391 – 400.

Rahman, M. S. and Lamb, J. (1991): Air drying behavior of fresh and osmotically dehydrated pineapple, *J Food Process Eng* 14, 163–171.

Sakpere A. M., Ayisire E. R., Abioye O. I. (2011): Potential of Launea taraxacifolia (Willd) Amin Ex. C. Jeffrey for in Vitro Regeneration, *Notulae Scientia Biologicae* 3, 93-96.

Schippers, R.R. (2000): African indigenous vegetables. An overview of the cultivated species. Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation, Chatham, United Kingdom.

Slavin, J. L. and Lloyd, B. (2012): Health benefits of fruits and vegetables, *Advances in Nutrition* 3 (4), 506-516. https://doi.org/10.3945/an.112.002154

Usub, T., Lertsatitthankorn, C., Poomsa-ad, N., Wiset, L., Siriamornpun, S., and Soponronnarit, S. (2010): Thin layer solar drying characteristics of silkworm pupae, *Food and Bioproducts Processing* 88(2-3), 149–160. https://doi.org/10.1016/j.fbp.2009.04.002

Wellytton, D. Q., Valdiney, C. S., Geraldo, A. M., Eder, P. I., Rafael, A. L., Lucas, R. F., Renata, H. H., Vanderleia, S., Rodrigo, A. J., André, L. D. G. and Elton, A. S. M. (2019): Mathematical Modeling of Thin-Layer Drying Kinetics of Piper aduncum L. Leaves, *Journal of Agricultural Science* 11 (8), 225 – 235.

Yekeen T., Adetiba O., Azeez M., Falodun M., Akintaro S., TA Y. (2011): Studies on the proximate analysis of Solanum aethiopicum, Lactuca taraxacifolia and Talinum triangulare and potential cytotoxic effects of theri aqeous extracts using Allium cepa assay, *Annals of Biological Research* 2, 696-706.