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Effect of pretrature with ultrasound in convention drying kinetics of bananas (*Musa paradisiaca*)

Efecto del pretratamiento con ultrasonido en la cinética de secado convencional de banano *(musa paradisiaca)*

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ABSTRACT

Keywords:

Bananas, Conservation, Convection drying, Humidity, Ultrasound.

The use of ultrasound in food processing has increased in the last decade due to the reduction in times, temperatures, microbial and enzymatic inactivation, extraction of components of great interest to different industries; without altering or modifying its nutritional or organoleptic value during the transformation processes of raw materials into products with added value. Considering itself, a green technology by not causing a negative impact on the environment. In this work, the effect of US pretreatment (40KHz/130W/30°C /10, 20 and 30 min) on convective drying at 60°C / 2m / s of banana (*Musa paradisiaca*) was evaluated. A diffusion model was used to describe the drying kinetics and to quantify the influence of the US on the effective diffusivity of water. Observing that the US significantly increased (p> 0.05) the drying speed in all the samples treated with an average reduction of 31% in the drying time with respect to the control treatment; reaching a weight loss of 77% with respect to the initial weight (3.8 to 0.9 g.). The exponential model is the most adequate to predict the experimental curves of banana drying and showed that the application of US increased both the effective diffusivity and the mass transfer coefficient, as corroborated by the values of the explained variance of 98.5 a 99.3%.

RESUMEN

Palabras clave:

Plátanos, Conservación, Secado por convección, Humedad, Ultrasonido.

El uso del ultrasonido en el procesamiento de alimentos se ha incrementado en la última década debido a la reducción en tiempos, temperaturas, inactivación microbiana y enzimática, extracción de componentes de gran interés para diferentes industrias; sin alterar o modificar su valor nutricional u organoléptico durante los procesos de trasformación de las materias primas en productos con valor agregado. Considerándose, una tecnología verde al no causar impacto negativo al medio ambiente. En este trabajo se evaluó el efecto del pretratamiento con US (40 KHz/130W/30°C /10, 20 y 30 min) en el secado convectivo a 60°C/2m/s del banano (*Musa paradisiaca*). Se utilizó un modelo difusional para describir las cinéticas de secado y cuantificar la influencia del US en la difusividad efectiva de agua. Observando que el US incrementó significativamente (p>0.05) la velocidad de secado en todas las muestras tratadas con una reducción promedio del 31% en el tiempo de secado con respecto al tratamiento control; alcanzando una pérdida de peso del 77% respecto del peso inicial (3.8 a 0.9 g.). El modelo exponencial es el más adecuado para predecir las curvas experimentales de secado del banano y mostró que la aplicación de US aumentó tanto la difusividad efectiva y el coeficiente de transferencia de masa, como corroboran los valores del porcentaje de varianza explicada de 98.5 a 99.3%.

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[18] S.F. Sulaiman *et al*., "Correlation between total phenolic and mineral contents with antioxidant activity of eight Malaysian bananas (*Musa sp.*)", *Journal of Food Composition and Analysis*, vol. 21, no. 1, pp. 1–10, 2011. https://doi.org/10.1016/j.jfca.2010.04.005

[19] I.S. Arvanitoyannis and A. Mavromatis, "Banana cultivars, cultivation practicrs, and physicochemical properties", *Critical Reviews in Food Science and Nutrition*, vol. 49, no. 2, pp. 113–135, 2009. https://doi.org/10.1080/10408390701764344

[20] V.A. Adisa and E.N. Okey, "Carbohydrate and protein composition of banana pulp and peel as influenced by ripening and mold contamination", *Food Chemistry*, vol. 25, no. 2, pp. 85–91, 1987. https://doi.org/10.1016/0308-8146(87)90057-4

[21] F.L. Lukezic, W.J. Kaiser and M.M. Martinez, "The incidence of crown rot of boxed bananas in relation to microbial populations of the crown tissue", *Canadian Journal of Botany*, vol. 45, no. 4, pp. 413–421, 1967. https://doi.org/10.1139/b67-041

[22] P.H. Machado de Sousa *et al*., "Influência da concentração e da proporção fruto:xarope na desidratação osmótica de bananas processadas", *Ciencia y Tecnología de los Alimentos*. vol. 23, pp. 126–130, 2003. https://doi.org/10.1590/S0101-20612003000400024

[23] A. Martynenko and T. Kudra, "Quality drying of medicinal plants, in: Proceedings of 19th international drying symposium", 24–27.08.2014, Lyon, Fr. EDP Sci. 2014. ISBN 978-2-7598-1631-6, pp.7, 2014.

[24] A. Esehaghbeygi, K. Pirnazari and M. Sadeghi, "Quality assessment of electrohydrodynamic and microwave dehydrated banana slices", *LWT - Food Science and Technology*, vol. 55, no. 2, pp. 565–571, 2014. https://doi.org/10.1016/j.lwt.2013.10.010

[25] A.A. Silva, J.L. Barbosa-Junior and M.I.M. Jacintho-Barbosa, "Green banana flour as a functional ingredient in food products", *Ciencia Rural*, vol. 45, no. 12, pp. 2252-2258, 2015. https://doi.org/10.1590/0103-8478cr20140332

[26] M. P.A. Maunahan, J.M. Nuevo and J. Resorez, "The role of gender in maintaining quality and reducing postharvest losses: The case of 'Bungulan' (*Musa genome AAA*) bananas for export", *Acta Horticulturae*, pp. 21-27, 2018. https://doi.org/10.17660/ActaHortic.2018.1210.3

[27] S.J. Babalis and V.G. Belessiotis, "Influence of the drying conditions on the drying constants and moisture diffusivity during the thin-layer drying of figs", *Journal of Food Engineering*, vol. 65, no. 3, pp. 449–458, 2004. https://doi.org/10.1016/j.jfoodeng.2004.02.005

[28] J. Crank, *The Mathematics of Diffusion.* London, Reino Unido: Oxford University Press, 1975.

[29] A. Vega-Gálvez, L. Puente-Díaz, R. Lemus-Mondaca and M. Miranda, "Mathematical modeling of thin-layer drying kinetics of cape gooseberry (Physalis peruviana L.)", *Journal of Food Processing and Preservation*, vol. 38, no. 2, pp. 728-736, 2012. https://doi.org/10.1111/jfpp.12024

[30] Y. Lin, J. Tsen and V. King, "Effects of far-infrared radiation on thefreeze-drying of sweet potato", *Journal of Food Engineering*, vol. 68, no. 2, pp.249–255, 2005. http://doi.org/10.1016/j.jfoodeng.2004.05.037

[31] I. Doymaz, "Convective drying kinetics of strawberry", *Chemical Engineering and Processing*, vol. 47, no. 5, pp. 914-919, 2008. https://doi.org/10.1016/j.cep.2007.02.003

[32] W. Senadeera, B.R. Bhandari, G. Young and Y.B. Wijesinghe, "Influence of shapes of selected vegetable materials on drying kinetics during fluidized bed drying", *Journal of Food Engineering*, vol. 58, no. 3, pp.277–283,2003. https://doi.org/10.1016/S0260-8774(02)00386-2

[33] I.T. Togˇ Rul and D. Pehlivan, "Modeling of drying kinetics of simple apricot", *Journal of Food Engineering*, vol. 58, no. 1, pp. 23–32, 2003. https://doi.org/10.1016/S0260-8774(02)00329-1

[34] L. Puente-Díaz, E. Echegaray-Pacheco, E. Castro-Montero and K. Di-Scala, "Application of mathemathical models to infrared assisted drying process of lemon waste *(citrus limon (l.) burm. f. cv. genova*)", *Dyna*, vol. 80, no. 181, pp. 91-97, 2013.

[35] Y. Ozdemir, A. Ozturk and S. Tüfekçi, "Effect of two dipping pretreatment on drying kinetics of golden berry (Physalis peruviana L.)" *African Journal of Agricultural*, vol. 11, no. 1, pp. 40-47, 2016. https://doi.org/10.5897/AJAR2014.8937

[36] G. Yıldız, N. İzli, H. Ünal and V. Uylaşer, "Physical and chemical characteristics of goldenberry fruit (Physalis peruviana L.)", *Journal of Food Science and Technology*, vol. 52, no. 4, pp. 2320–2327, 2015. https://doi.org/10.1007/s13197-014-1280-3

[37] J.E. Vásquez-Parra, C.I. Ochoa-Martínez and M. Bustos-Parra, "Effect of chemical and physical pretreatments on the convective drying of cape gooseberry fruits (*Physalis peruviana*)", *Journal of Food Engineering*, vol. 119, no. 3, pp. 648–654, 2013. https://doi.org/10.1016/j.jfoodeng.2013.06.037

[38] A. Ayala-Aponte, L. Serna-Cock, J. Libreros-Triana, C. Prieto and K. Di-Scala, "Influence of osmotic pre-treatment on convective drying of yellow pitahaya", *DYNA*, vol. 81, no. 188, pp.145-151, 2014. https://doi.org/10.15446/dyna.v81n188.41321

[39] J. García-Pérez, C. Ozuna, C. Ortuño, J. Cárcel and A. Mulet, "Modelling ultrasonically assisted convective drying of eggplant", *Drying Technology*, vol. 29, no. 13, pp.1499-1509, 2011. https://doi.org/10.1080/07373937.2011.576321

[40] A. Wiktor, M. Sledz, M. Nowacka, K. Rybak and D. Witrowa-Rajchert, "The influence of immersion and contact ultrasound treatment on selected properties of the apple tissue", *Applied Acoustics*, vol. 103, pp.136-142, 2016. https://doi.org/10.1016/j.apacoust.2015.05.001

[41] F. Fernandes, M. Gallão and S. Rodrigues, "Effect of osmotic dehydration and ultrasound pre-treatment on cell structure: Melon dehydration", *LWT – Food Science and Technology*, vol. 41, no. 4, pp. 604–610,2008. https://doi.org/10.1016/j.lwt.2007.05.007

[42] F. Fernandes, M. Gallão and S. Rodrigues, "Effect of osmosis and ultrasound on pineapple cell tissue structure during dehydration", *Journal of Food Engineering*, vol. 90, no. 2, pp. 186–190, 2009. https://doi.org/10.1016/j.jfoodeng.2008.06.021

[43] F. Fernandes, M. Gallão and S. Rodrigues, "Effect of immersion time in osmosis and ultrasound on papaya cell structure during dehydration", *Drying Technology*, vol.27, pp.220-225, 2009. https://doi.org/10.1080/07373930802605883

[44] J. Gamboa-Santos, A. Montilla, A. Soria, J. Cárcel, J. García-Pérez and M. Villamiel, "Impact of power ultrasound application on the quality of convective dried Strawberries", tesis doctoral, Universidad Autónoma De Madrid, 2013.

[45] J. Garcia-Noguera *et al*., "Ultrasound-Assisted Osmotic Dehydration of Strawberries: Effect of Pretreatment Time and Ultrasonic Frequency". *Drying Technology*, vol. 28, no. 2, pp. 294–303, 2010. https://doi.org/10.1080/07373930903530402

[46] H. Wang *et al*., "Pretreatment of ultrasound combined vacuum enhances the convective drying efficiency and physicochemical properties of okra (*Abelmoschus esculentus*)", *LWT*, vol. 112, 2019. https://doi.org/10.1016/j.lwt.2019.05.099

[47] Z. Allahdad, M. Nasiri, M. Varidi and M.J. Varidi, "Effect of sonication on osmotic dehydration and subsequent air-drying of pomegranate arils", *Journal of Food Engineering*, vol. 244, pp. 202-211, 2019. https://doi.org/10.1016/j.jfoodeng.2018.09.017

[48] M.L. Rojas and P.E.D. Augusto, "Ethanol and ultrasound pre-treatments to improve infrared drying of potato slices", *Innovative Food Science & Emerging Technologies*, vol. 49, pp. 65-75, 2018. https://doi.org/10.1016/j.ifset.2018.08.005

[49] M.L. Rojas, P.E.D. Augusto and J.A. Cárcel, "Ethanol pre-treatment to ultrasound-assisted convective drying of apple", *Innovative Food Science & Emerging Technologies*, vol. 61, 102328, 2020. https://doi.org/10.1016/j.ifset.2020.102328

[50] M.L. Rojas, I. Silveira I and P.E.D. Augusto, "Ultrasound and etanol pre-treatments to improve convective drying: Drying, rehydration and carotenoid content of pumpkin", *Food and Bioproducts Processing*, vol. 119, pp. 20-30, 2019. https://doi.org/10.1016/j.fbp.2019.10.008

[51] C. Ozuna, T.G. Álvarez-Arenas, E. Riera, J.V. Cárcel, J.A. García-Pérez, "Ultrasonics Sonochemistry Influence of material structure on air-borne ultrasonic application in drying", *Ultrasonics Sonochemistry*, vol. 21, no. 3, pp. 1235–1243, 2014. https://doi.org/10.1016/j.ultsonch.2013.12.015

[52] Y. Campo-Vera, D. Villada and O. Gélvez, "Efecto de la aplicación de ultrasonido sobre las cinéticas de secado convectivo de fresa (*Fragaria vesca*)", *Vitae*, vol. 23, no.1, pp.100 – 104, 2016.

[53] J. Kroehnke, G. Musielak and A. Boratynska, "Convective drying of potato assisted by Ultrasound". pp.57-65, 2014.

[54] Z. Chen, X. Guo and T. Wu, "A novel dehydration technique for carrot slices implementing ultrasound and vacuum drying methods", *Ultrasonics Sonochemistry*, vol. 30, pp. 28-34, 2016. https://doi.org/10.1016/j.ultsonch.2015.11.026

[55] M. Sledz, A. Wiktor, K. Rybak, M. Nowacka and D. Witrowa-Rajchert, "The impact of ultrasound and steam blanching pre-treatments on the drying kinetics, energy consumption and selected properties of parsley leaves", *Applied Acoustics*, vol. 103, part B, pp. 148-156, 2016. https://doi.org/10.1016/j.apacoust.2015.05.006

[56] E. Riera, J. García-Pérez, J. Cárcel, V. Acosta and J. Gallego-Juárez, *Computational study of ultrasound-assisted drying of food materials*, Innovative Food Processing Technologies: Advances in Multiphysics Simulation. John Wiley & Sons Ltd., 2011. https://doi.org/10.1002/9780470959435.ch13

[57] G. Sharma, R. Verma and P. Pathare, "Mathematical modeling of infrared radiation thin-layer drying of onion slices", *Journal of Food Engineering*, vol. 71, no.3, pp. 282-286, 2005. https://doi.org/10.1016/j.jfoodeng.2005.02.010