

**EFFECTS OF PRE-TREATMENT ON THE DRYING CHARACTERISTICS
OF SQUASH (*Cucurbita maxima*)**

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ABSTRACT

PERALTA, JOYCELLE B., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, **JUNE 2023, EFFECTS OF PRE-TREATMENT ON THE DRYING CHARACTERISTICS OF SQUASH (*Cucurbita maxima*)**

Adviser: NOVALYN G. DELOS SANTOS, M.Sc.

Squash (*Cucurbita maxima*) is one of the vegetables with high nutritional content that may be utilized in a range of foods and medications.

This study was conducted to determine the effects of pre-treatment on the drying characteristics of squash using Multi-Commodity Solar Tunnel Dryer (MCSTD). The drying characteristics and quality attributes of dried products can be influenced by the pre-treatments and drying method. As pre-treatment of squash, blanching at different temperature and brining at different amount of salt solution were applied to improve the quality of dried squash. Evaluation of the MCSTD for drying of the abovementioned commodity determined the effects of the pre-treatments in terms of drying capacity, drying period, and moisture reduction rate. Also, drying characteristics and quality attributes were determined.

The drying zone labeled as Block I, Block II and Block III. Block I was placed near the blower, Block II was placed at the middle part and the Block III was placed at end part of dryer. Based on the result of the study, the temperature near the blower (Block I) got the lowest temperature and highest relative humidity among the blocks. Also, the weight of the sliced squash placed near the blower (Block I) has a lower moisture reduction loss. In contrast, the drying zone at the end part of the dryer (Block III) exhibited a superior moisture loss, since the temperature at the end part of the dryer is the highest from 11:00

am – 5:00 pm. The results indicate that drying temperature has a direct relationship with moisture reduction.

The drying lasted for 4 days to attain the ideal moisture content for the safe storage of dried squash which is 5%, so it significantly affects the color. As a result, brining at 5% salt solution (ST1) was the darkest among other treatments, while the samples dipped in tap water for 10 minutes (Control 2) are the lightest. On the other hand, moisture content of blanching is low compared to salting, after drying. Total Soluble Solids (TSS) of dried squash except brining at 5% salt solution (ST1) and brining at 10% salt solution (ST2) was found to be higher when compared to the TSS content of fresh squash. However, brining at 15% salt solution (ST3) exhibited superior among other with respect to TSS. Brining has a water activity ranging from 0.48-0.60, whereas the water activity in blanching were ranging from 0.44-0.46 only. Samples washed only in tap water (Control 1) and samples pre-treated with 5% salt solution (ST1) exhibited a superior quality in terms of color, taste, flavor, mouth-feel, overall acceptability, and preference of evaluators. Moreover, samples pre-treated with 5% salt solution (ST1) was considered to be the optimum pre-treatment among others, since the rating description for individual attribute liking in terms of overall acceptability has a rating description of “like moderately”.

LITERATURE CITED

- Abu-Ghannam, N., & Jaiswal, A. K. (2015). Blanching as a treatment process: effect on polyphenol and antioxidant capacity of cabbage. <https://doi.org/10.1016/B978-0-12-404699-3.00005-6>
- Agrawal, A., & Sarviya, R. M. (2014). A review of research and development work on solar dryers with heat storage. doi:10.1080/14786451.2014.930464
- Anitha, S., Ramya, H., & Ashwini, A. (2020). Effect of mixing pumpkin powder with wheat flour on physical, nutritional and sensory characteristics of cookies. <https://doi.org/10.22271/chemi.2020.v8.i4g.9737>
- Barrett, D., Beaulieu, J. & Shewfelt, R. (2010). Color, Flavor, Texture, and Nutritional Quality of Fresh-Cut Fruits and Vegetables: Desirable Levels, Instrumental and Sensory Measurement, and the Effects of Processing. <http://www.fruitandvegetable.ucdavis.edu/files/217117.pdf>
- Birwal, P., Singham, P., & Yadav, B.K. (2015). Importance of Objective and Subjective Measurement of Food Quality and their Inter-relationship. Food Processing & Technology. <https://www.longdom.org/open-access/importance-of-objective-and-subjective-measurement-of-food-quality-and-their-interrelation-ship.pdf>
- Borro, R. & Gemora, R. (2016). Sensory Acceptability of Squash (*Cucurbita maxima*) in Baking Cake. <https://asset-pdf.scinapse.io/prod/2504953241/2504953241.pdf>
- Bureau of Agricultural Research. (2012). Squash. <https://www.bar.gov.ph/index.php/agfishtech-home/crops/207-vegetables/1301-squash>
- Caliskan G. & Dirim, N. (2012). Determination of the effect of freeze drying process on the production of pumpkin (*Cucurbita moschata*) puree powder and the powder properties. <https://www.researchgate.net/publication/268034201>
- Caliskan, G., & Dirim, S. N. (2017). Drying characteristics of pumpkin (*Cucurbita moschata*) slices in convective and freeze dryer. Heat and Mass Transfer. <https://doi:10.1007/s00231-017-1967-x>
- Capariño, O. (2012). Mango (Philippine 'Carabao' var.) powder made from different drying system. https://research.libraries.wsu.edu:8443/xmlui/bitstream/handle/2376/4271/Caparino_wsu_0251E_10486.pdf
- Dairy Research and Information Center. (2017). Water Activity in Food. <https://drinc.ucdavis.edu/dairy-food-sciences/water-activity-food>

- De la Torre, J. M. (2002). Dryer for fish, mango promising. https://www.PHilMech.gov.ph/?page=story_full_view&action=story_fullview&recordID=0000000073&recordCategory=News
- Department of Agriculture. (2017). Squash Production Guide. <http://rfo02.da.gov.ph/high-value-crops-iec-materials/>
- Department of Food Science. (2020). Sensory Evaluation Concentration. <https://foodscience.cals.cornell.edu/graduate/ms-and-phd-research-concentration/sensory-evaluation-concentration>
- Driessen, S. (2020). Drying food at home. <https://extension.umn.edu/preserving-and-preparing/drying-food>
- Food and Drug Administration. (2014). Water Activity (aw) in Foods. <https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/inspection-technical-guides/water-activity-aw-foods>
- Galindo, M. M., Schneider, N. Y., Stähler, F., Töle, J., & Meyerhof, W. (2012). Taste Preferences. *Recent Advances in Nutrigenetics and Nutrigenomics*, 383–426. doi:10.1016/b978-0-12-398397-8.00015-0
- Gatea, A. (2011). Performance evaluation of a mixed-mode solar dryer for evaporating moisture in beans. https://academicjournals.org/article/article1379432471_Gatea.pdf
- Guiné, R. P. F., & Barroca, M. J. (2011). Effect of Drying on the Textural Attributes of Bell Pepper and Pumpkin. <https://doi:10.1080/07373937.2011.596297>
- Guiné, R. P. F., & Barroca, M. J. (2012). Effect of drying treatments on texture and color of vegetables (pumpkin and green pepper). <https://doi:10.1016/j.fbp.2011.01.003>
- He, C., Wang, H., Yang, Y., Huang, Y., Zhang, X., Arowo, M., & Xiao, M. (2021). Drying behavior and kinetics of drying process of plant-based enteric hard capsules. <https://sci-hub.se/10.3390/pharmaceutics13030335>
- International Rice Research Institute. (n. d.). *Drying*. Retrieved from <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/drying#tradditional-drying-systems>
- Khatib, S. & Muhieddine, M. (2019). Nutritional Profile and Medicinal Properties of Pumpkin Fruit Pulp. <https://www.intechopen.com/books/>

- Kroll, J.J., & Popper, R. 2011. Developing Children's Food Products. Hedonic Scales. <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hedonic-scales>
- Kulkarni, A. S., & Joshi, D. C. (2013). Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. <https://www.proquest.com/openview/484433d78eee22ed6388a95787da3936/1?pq-origsite=gscholar&cbl=816390>
- Lawless, H. (1991). The sense of smell in food quality and sensory evaluation. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1745-4557.1991.tb00046.x>
- Maina, J. W. (2018). Analysis of the factors that determine food acceptability. <https://www.thepharmajournal.com/archives/2018/vol7issue5/PartD/7-4-84-339.pdf>
- Mala, S. K., Aathira, P., Anjali, E. K., Srinivasulu, K., & Sulochanamma, G. (2018). Effect of pumpkin powder incorporation on the physico-chemical, sensory and nutritional characteristics of wheat flour muffins. [http://www.ifrj.upm.edu.my/25%20\(03\)%202018/\(27\).pdf](http://www.ifrj.upm.edu.my/25%20(03)%202018/(27).pdf)
- Miranda, L. N., Asuncion, N. T., Flores, E. D., & Martinez, R. (2003). Adaptability testing of existing dryers for non-grain commodities. Science City of Muñoz, Nueva Ecija, Philippines: Bureau of Postharvest Research and Extension.
- More, M. & Tayade, D. (2019). Effect of Drying, Blanching and Rehydration Behavior on the Quality of Green Peas. <https://doi.org/10.20546/ijcmas.2019.803.277>
- Neikov, O. D. (2009). Processing of powders and processing equipment. In Handbook of Non-Ferrous Metal Powders. <https://www.torrossa.com/it/resources/an/5369792>
- O'Mahony M. (1991). Taste perception, food quality and consumer acceptance. <https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1745-4557.1991.tb00045.xcrd>
- Pomeranz, Y. & Meloan C. (2020). Determination of Moisture. https://link.springer.com/chapter/10.1007/978-1-4615-6998-5_34
- Pongjanta, J., Naulbunrang, A., Kawngdang, S., Manon, T., & Thepjaikat, T. (2006). Utilization of pumpkin powder in bakery products. Songklanakarin <https://www.thaiscience.info/Journals/Article/SONG/10462637.pdf>

- Rajal, K. S., Taip, F. S., Azmi, M. M. Z., & Shishir, M. R. I. (2017). Effect of pre-treatment and different drying methods on the physicochemical properties of *Carica papaya* L. leaf powder. <https://doi:10.1016/j.jssas.2017.04.001>
- Raju, V., Meenakshi, R. & Siva, E. (2013). Design and Fabrication of Efficient Solar Dryer. https://www.ijera.com/papers/Vol3_issue6/II3614451458.pdf
- Reshmi, N. P., Mandal, G. & Thokchom, R. (2018). Effect of Pre-Treatment of Salt Solution and Drying Methods on the Quality of Processed Aonla (*Emblica officinalis* Gaertn.). <https://www.ijcmas.com/7-8-2018/Nirmala%20Prabhu%20Reshmi,%20et%20al.pdf>
- Roongruangsri, W. & Bronlund, J. E. (2015). A Review of Drying Processes in the Production of Pumpkin Powder. <https://doi.org/10.1515/ijfe-2015-0168>
- Sharma, M., Prakash, O., Sharma, A., & Kumar, A. (2018). Fundamentals and Performance Evaluation Parameters of Solar Dryer. https://doi:10.1007/978-981-10-7326-7_3
- Song, J., Wang, X., Li, D., & Liu, C. (2017). Degradation kinetics of carotenoids and visual colour in pumpkin (*Cucurbita maxima* L.) slices during microwave-vacuum drying. <https://doi:10.1080/10942912.2017.1306553>
- Suwan, P. (2015). Effects of blanching on color, texture and sodium chloride content during storage time of frozen vegetable soybean modeling for commercial scale. <https://digitalcommons.unl.edu/cgi/viewcontent.cgi>
- Suzauddula, M., Miah, M., Mukta, N., Kamrul, N. & Hossain, M. (2019). Kinetics study on dried *Moringa oleifera* leaves during sun drying, multi commodity solar tunnel dryer drying and oven drying. <https://sciendo.com/article/10.2478/mjhr-2019-003>
- Tepper, L. M. (2013). *Squash Production Guide*. Retrieved from http://bpi.da.gov.ph/bpi/images/Production_guide/pdf/PRODUCTIONGUIDE-SQUASH.pdf
- Toshniwal, U. & Karale, S. R. (2013). A review paper on Solar Dryer. https://www.ijera.com/papers/Vol3_issue2/ER32896902.pdf
- Udomkun, P., Romuli, S., Schock, S., Mahayothee, B., Sartas, M., Wossen, T.,...Müller, J. (2020). Review of solar dryers for agricultural products in Asia and Africa: An innovation landscape approach. <https://doi:10.1016/j.jenvman.2020.110730>

- Wang, H., Fu, Q., Chen, S., Hu, Z. & Xie, H. (2017). Effect of Hot-Water Blanching Pretreatment on Drying Characteristics and Product Qualities for the Novel Integrated Freeze-Drying of Apple Slices. <https://www.hindawi.com/journals/jfq/2018/1347513/>
- Whyte, J., Nazario, B., Pathak, N., Bhargava, H. & Smith, M. (2016). Pumpkin Powder: Is It Good for You. <https://www.webmd.com/diet/pumpkin-powder>
- Workneh, T. S., Zinash, A., & Woldetsadik, K. (2012). Blanching, Salting and sun drying of different pumpkin fruit slices. <https://doi:10.1007/s13197-012-0835-4>
- Zambrano, M., Duttaa, B., Mercer, D., Macleana, H. & Touchiea, M. (2019). Assessment of moisture content measurement methods of dried food products in small-scale operations in developing countries: A review. <https://www.sciencedirect.com/science/article/pii/S0924224418304898>