



# Refractance Window Drying Technology

BENEFITS AND COMPETITIVE ADVANTAGE

# Benefits and Value

- ▶ Produce high quality products while retaining heat sensitive vitamins, color, phytochemicals and antioxidant activity close the freeze dried products<sup>1</sup>
- ▶ Retention of more bioactive components of the final product<sup>2</sup>
- ▶ Preservation of ascorbic acid content is comparable to that of Freeze drying<sup>3</sup>
- ▶ Greater retention of anthocyanin levels compared to conventional drying methods with upper 93 percentile retention<sup>4</sup>
- ▶ Carotene retention similar to that of Freeze drying<sup>5</sup>
- ▶ Cost of RW dryers are 70% cheaper than Freeze dryers and utilize 50% less energy than Freeze dryers lowering carbon footprint and greenhouse gasses<sup>6</sup>
- ▶ Modular design allows for greater flexibility on plant locations
- ▶ Closer to the point of the raw product production
- ▶ Vitamin B retention is higher in studies of blueberries, tart cherries and strawberries using Refractance Window drying over Freeze drying<sup>7</sup>
- ▶ Microbial reduction load in one study resulted in 4.6, 6.1, 6.0 and 5.5 log reductions in total aerobic plate count, coliforms, e-coli and Listeria innocua.<sup>8</sup> Finished moisture consistently below 5% and often below 3%.

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<sup>1</sup>Baeghballi V, Niakosari M, Kiani M. Design, manufacture and investigating functionality of a new batch Refractance Window system. In: Proceedings of 5th International Conference on Innovations in Food and Bioprocess Technology. 2010:7(9).

<sup>2</sup>Aboufadi M, Ghanem T. Effect of Refractance-window (RW) drying method on quality criteria of produced tomato powder as compared to the convection drying method. In: World Applied Sciences Journal. 2018.

<sup>3</sup>Ocoró-Zamora M, Ayala-Aponte A. Influence of thickness on the drying of papaya puree (*Carica papaya* L.) through refractance window™ technology. In: DYNA. 2022.

<sup>4</sup>Bonat Celli G, Khattab R, Ghanem A, Su-Ling Brooks M. Refractance Window™ drying of haskap berry— preliminary results on anthocyanin retention and physicochemical properties. In: Food Chemistry. 2016.

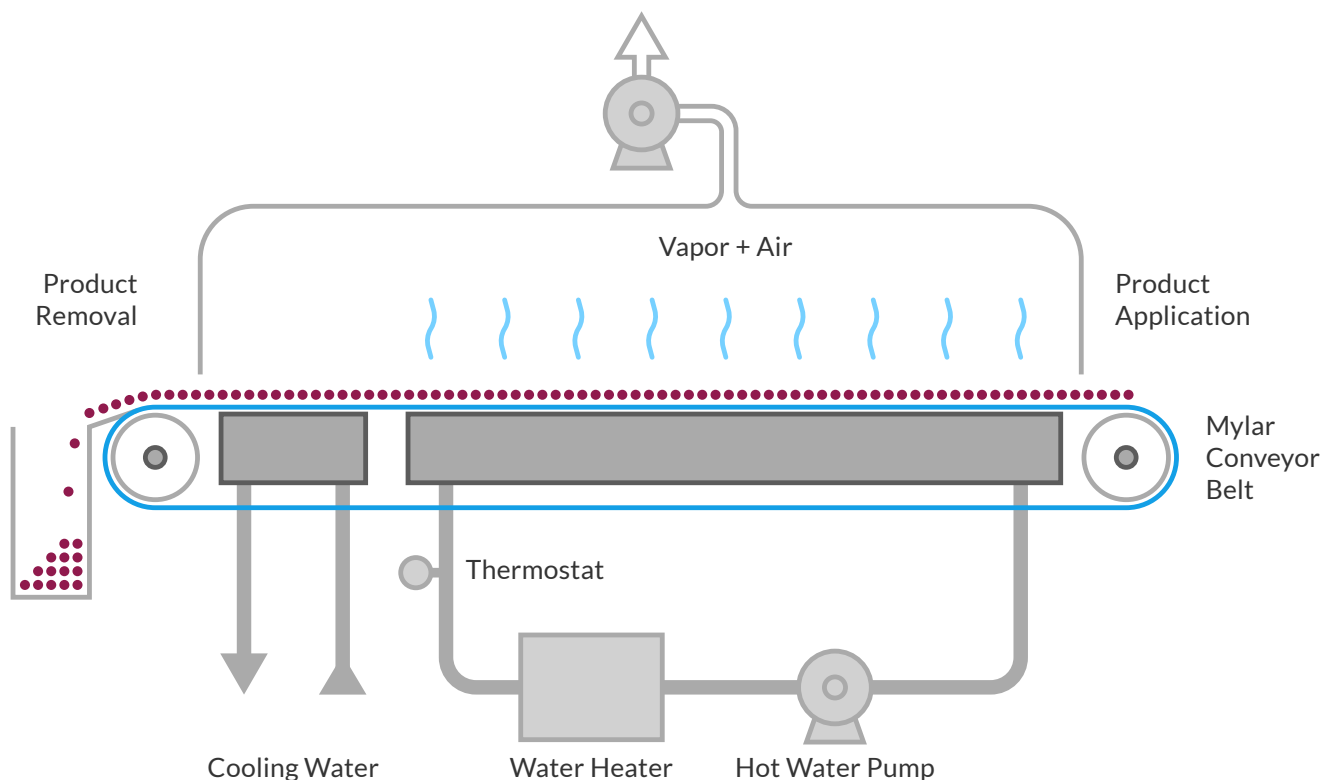
<sup>5</sup>B.I. Abonyi, H. Feng, J. Tang, C.G. Edwards, B.P. Chew, D.S. Mattinson, J.K. Fellman. Quality Retention in Strawberry and Carrot Purees Dried with Refractance Window™ System. In: Journal of Food Science. 2006.

<sup>6</sup>C. I. Nindo, J. Tang. Refractance Window Dehydration Technology: A Novel Contact Drying Method. In: Drying Technology. 2007.

<sup>7,8</sup>Boris Nemzera, Luis Vargas, Xiaoyan Xia, Marsha Sintara, Hao Feng. Phytochemical and physical properties of blueberries, tart cherries, strawberries, and cranberries as affected by different drying methods. In: Food Chemistry. 2018.

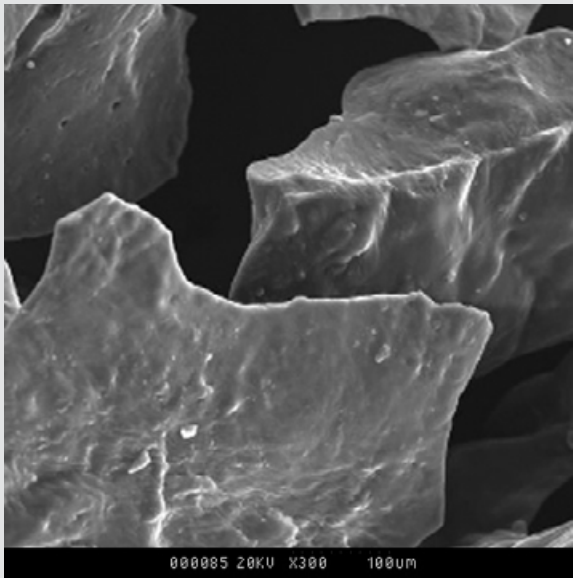
## Technology

- ▶ Uses circulating hot water & steam to indirectly convey thermal energy (conduction) through a thin mylar belt which holds a layer of slurry on top. The thermal energy transfer begins to dehydrate the product from the underside while maintaining relatively low temperatures inside the cells of the product (85°C-94°C)
- ▶ Additionally, the thin mylar belt is encapsulated in a tunnel with convection air creating turbulence to further evaporate moisture from the top of the slurry.
- ▶ Less need for excipients, processing aids or flow agents
- ▶ Additions of processing aids similar to arabic gum (fiber) can increase throughput of product and further reduce COGS.
- ▶ Final product easily dispersed in solution with little to no residue nor clumping



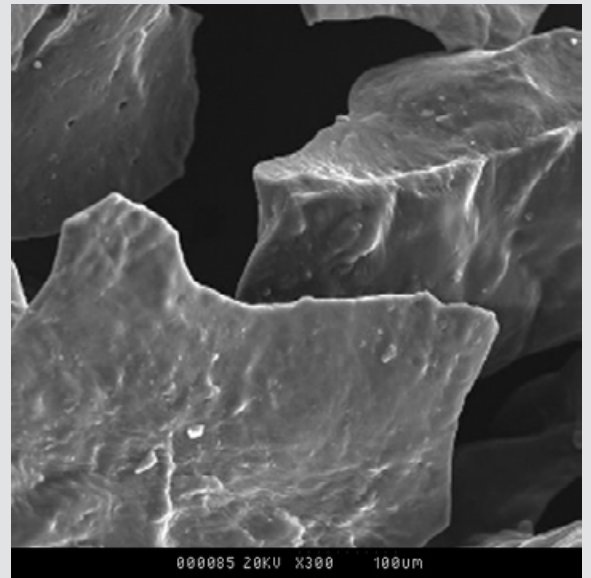
Watch the Refractance Window dryer in action

## SPRAY DRYING



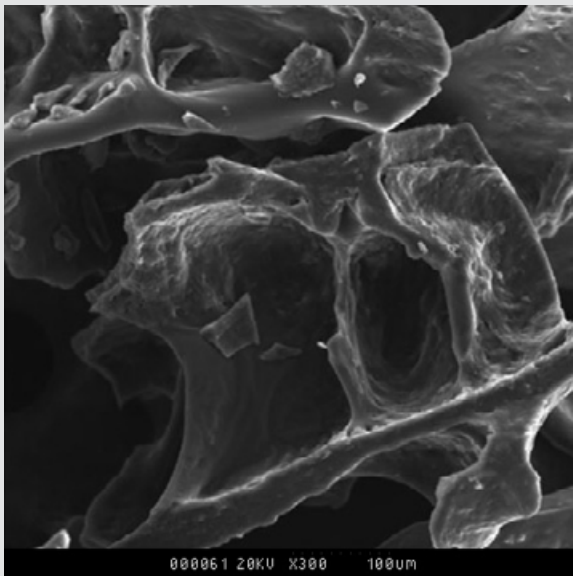
- ▶ Extreme heat (200 - 300° C)
- ▶ Carriers often used
- ▶ Color, phytonutrient, micronutrient degradation
- ▶ Spherical microstructure causes shelf life instability and oxidation

## DRUM DRYING



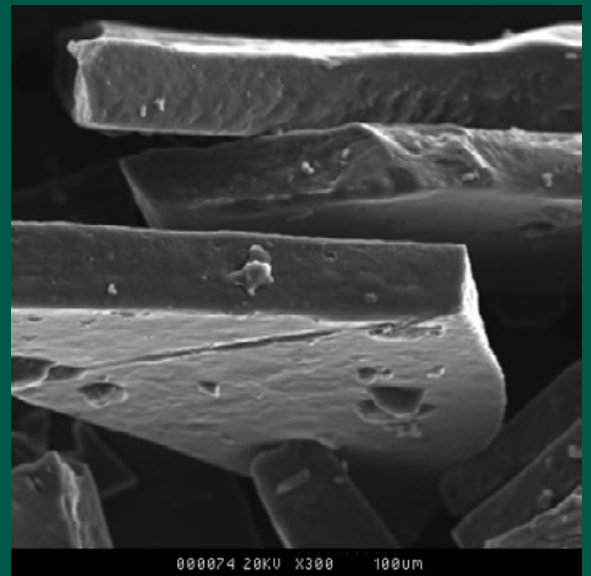
- ▶ Extreme heat (110 - 160° C)
- ▶ Color, phytonutrient, micronutrient degradation
- ▶ Highly irregular/jagged dried microstructure

## FREEZE DRYING



- ▶ Exposure to extreme pressures
- ▶ Long drying times (32 hours) equals nutrient loss
- ▶ Pretreatment with chemical inputs is common
- ▶ Highly porous finished-product

## REFRACTANCE WINDOW DRYING



- ▶ Low temp. drying, no carriers
- ▶ No extreme pressures or chemicals
- ▶ Microstructure is uniform and non-porous, which increases shelf life and reduces oxidation and microbial activity





## Spinaca's Competitive Advantage

- ▶ Year-round farming of over 20 fresh vegetables in Arizona, California, and Oregon for steady control of the raw product supply chain
- ▶ Certifications include: USDA Organic, NON-GMO, Kosher and GFSI
- ▶ Extensive food safety knowledge gained through multi-generational experience in the fresh vegetable market
- ▶ Historically we build our own harvesting equipment to continue to facilitate mechanical harvesting of products, constantly reducing the need for labor
- ▶ Owns all pre-processing and post-drying equipment to increase throughput and scalability of existing dryers
- ▶ Has the ability to build our own dryers once volumes permit to complete a fully vertically integrated model
- ▶ Family-owned and operated with no outside investors or partners







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