Refractance Window Drying: A Novel Contact Drying of Foods

A. S. Ghorband[1], Anurag Nema[1], V. B. Bhalodiya[1], S. P. Kulkarni[2]

[1]Department pf Food Process Engineering, College of Food Processing Technology & Bioenergy Anand Agricultural University, Anand, Gujarat

[2]MIT School of Food Technology, MIT ADT University, Lonikalbhor, Pune, Maharashtra

Corresponding Author:

Introduction

Drying is among the processing operations used to conserve fruits and vegetables. It lowers the water activity of food product, which restrains microbial growth and reduces deteriorative and non-enzymatic browning reactions. An additional key measure in selecting and evaluating a drying method is the effect of drying heat on nutrient retention because in dried foods nutritional losses are reliant upon the drying method used. Drying adversely affects the taste, colour, nutritional qualities of food products, enhances loss of bioactive compounds and aids in the formation of harmful compounds such as hydroxy methyl furfural (HMF) and other furfurals due to high temperatures maintained in the heat treatment, subjected to the products. Thus, substitutes of these drying processes are consequently sought to give superior quality and higher nutritional value. Refractance Window (RW) drying process is classified in the fourth generation of drying methods. Refractance Window drying process was invented and patented by Richard Magoon

Principle

Refractance Window Drying (RWD) is a new food drying technique where infrared heat and water vapor is used to dry food products. The process involves placing the food on a specially designed, transparent film that is heated by infrared radiation from below by circulating hot water. The moisture from the food then evaporates, and the dried product is removed from the film.

Polyester (Mylar), an infrared transparent plastic sheet transmits radiative heat to food during the RW drying process with higher drying rate, more retention of nutrients and low aroma and flavor loss.

Mechanism of working

1. The RW drying equipment working is based on the refractive principle of infrared radiations from the surface of hot circulating water.
2. This technology involves placing the pulpy wet product, as a uniform thin layer, on the top surface of an infrared transparent plastic sheet known as Mylar, a polyester film as shown in Fig. 1.
3. The transmissivity of Mylar film depends upon the thickness of the film as thin film shows more transparency to infrared radiations but its mechanical strength reduces when thickness lowers. Hence, the optimum thickness was determined as 0.25 mm.
4. The plastic sheet floats over heated water surface that carries thermal energy to the wet by combined conduction and infrared radiation.
5. The sheet was supported by the buoyant force of the water. This process used heated water at 95 to 97 °C temperature for remarkably efficient heat transfer through the combination of conduction, convection and radiation of heat leading to shorter drying times, which results in high quality products.

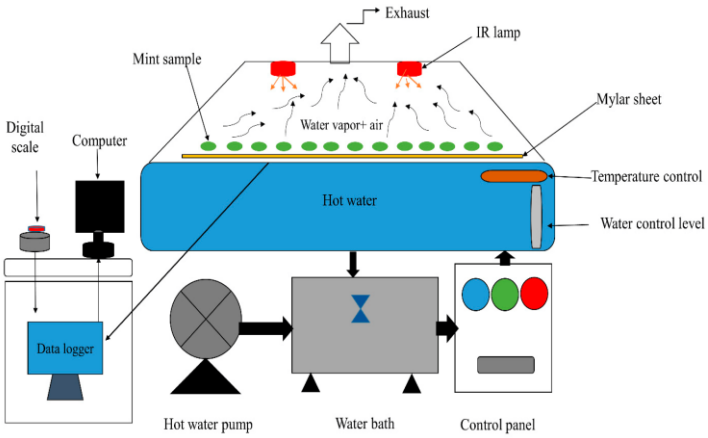

Fig. 1. Refractive window drying of foods

Advantages of refractance window drying

1. Preservation of Nutrients

- **Gentle drying method**: Refractance window drying uses lower temperatures than traditional drying techniques like hot air or freeze-drying. This helps protect antioxidants, vitamins, and other substances that are susceptible to being destroyed by extreme heat.
- **Better retention of flavor and color:** As the drying process is mild and controlled, the natural taste, color and aroma of the food commodities are better preserved, enhancing consumer acceptability.

2. Efficiency and Faster Drying

- **Reduced drying time:** RWD can effectively reduce drying time compared to traditional processing methods, especially when drying heat-sensitive foods. This is due to significant heat transfer from the infrared radiation and the continuous removal of moisture.
- **Higher energy efficiency:** It is energy-efficient than conventional drying methods like spray drying, freeze drying, or air drying, as it consumes less energy and time.

3. Better Quality

- **Uniform drying:** This method permits for uniform drying of food, minimizing issues like uneven texture or over-drying that commonly occurred in other methods.
- **Reduced shrinkage:** It allows foods undergo less shrinkage and maintain their original size and texture better than when dried using methods like hot air drying.

4. Preservation of Microbial Safety

- **Faster removal of moisture:** RWD ensures faster removal of moisture from food which reduces the risk of microbial growth, such as bacteria or molds, that generally flourish on moisture to grow.

5. Minimal Use of Additives

- **No need for preservatives:** This method reduces moisture content at certain level where microbial growth cannot occur. The mild, efficient drying process of RWD reduces the need for chemical preservatives.

6. Sustainability

- **Ecofriendly nature**: Because RWD uses less energy, creates less waste, and prevents the loss of important nutrients, it may be more sustainable than traditional drying techniques.
- **Scalability and versatility:** It is suitable for a wide range of food products like fruits, vegetables, purees, and herbs, making it versatile for various applications in the food industry.

7. Improved Shelf Life

- **Longer storage life:** By reducing moisture content efficiently while retaining food quality, RWD extends the shelf life of dried foods, making it an attractive option for food preservation and storage.

Disadvantages of refractance window drying

1. Expensive setup and maintenance

The machinery cost is more than traditional drying systems. The need for specialized transparent films, infrared heat sources, and precise control systems can make initial capital investment high. The transparent film that holds the food, may require regular maintenance or replacement, which adds to the operational costs over time.

2. Limited Scale-up Potential

While RWD can be very effective for small to medium-scale operations, scaling it up for large-scale industrial production can be challenging. The amount of food processed per unit of time may still be limited compared to large-scale drying methods like fluidized bed dryers or conveyor-belt hot air dryers.

3. Food Compatibility

It is highly suitable for foods with high moisture content (like purees, fruits, and vegetables), but it may not be as effective for other foods, particularly dense, solid foods or foods with irregular shapes.

4. Need for continuous monitoring

It requires skilled person to carry out drying in effectively and efficiently.

5. Dependence on Film Quality

The transparent film used in RWD plays a critical role in transferring proper heat and moisture removal from food. The film should be placed in good condition and this can require additional maintenance, especially if food particles or residues accumulate on it, affecting heat transfer and drying efficiency.

Applications of Refractance Window Drying in the Food Industry

1. **Fruit and Vegetable Drying**: Dehydrating fruits and vegetables, such as strawberries, mangoes, tomatoes, and leafy greens. The method helps retain the color, flavor, and nutritional value of these products, making it ideal for creating high-quality dried snacks, powders, and concentrates.
2. **Herbal and Medicinal Plants**: Companies can produce dried herbs and plant extracts with a higher level of bioactive compounds, maintaining their potency and effectiveness.

3. **Instant and Convenience Foods**: Instant soups, sauces, and ready-to-eat meals can be prepared. The technique preserves the original texture and flavor of ingredients, reducing the need for artificial additives and preservatives while ensuring a longer shelf life.
4. **Fruit Purees and Concentrates**: It is commonly used for fruit-based products such as apple, peach, and berry purees, which can be rehydrated into drinks, smoothies, or jams with retention of color and flavor.
5. **Dairy Products**: This method minimizes the loss of heat-sensitive proteins and nutrients, helping to preserve the quality and nutritional profile of dairy products (milk powder, yogurt powder) for use in various food applications.
6. **Functional Foods and Nutraceuticals**: It is used to process ingredients like probiotics, antioxidants, and dietary fibers.
7. **Organic and Natural Foods**: As consumers increasingly demand organic and natural products, refractance window drying offers a way to process these foods with minimal impact on their inherent properties.

Conclusion

Refractance window drying is gentle drying process can contribute to improved food safety by reducing microbial load without the use of preservatives. As research and technology evolve, it is likely that this drying technique will become more widely adopted, offering a valuable solution for the food industry's challenges in preserving food for longer storage and transportation without compromising quality.

References

Cao, W., & Liu, B. (2013). Refractance window drying: A new method for food dehydration. *International Journal of Food Science & Technology, 48*(6), 1097-1107. https://doi.org/10.1111/ijfs.12104

Mahapatra, D. M., Gupta, S. B., & Tiwari, S. R. (2016). Refractance window drying: A review. *Food Bioprocess Technology, 9*(7), 1079-1090.

Pérez-Gago, M. B., & Rojas, A. J. (2009). Refractance window drying of food products. *Food Control, 20*(11), 1087-1093. https://doi.org/10.1016/j.foodcont.2009.02.004

Bhandari, B. R., & Tong, G. J. (2020). Recent developments in food drying technology and refractance window drying: A review. *Innovative Food Science & Emerging Technologies, 62*, 102358. https://doi.org/10.1016/j.ifset.2020.100289

Thakur, M., & Goud, S. G. (2019). Technological advancements in refractance window drying of vegetables and fruits. *Journal of Food Engineering, 258*, 65-76. https://doi.org/10.1016/j.jfoodeng.2019.01.014

Prat, D., et al. (2020). Sustainable drying of foods: A review of refractance window drying and its future in food engineering. *Sustainable Food Production, 2*(1), 1-13. https://doi.org/10.1016/j.sfp.2020.02.003

Cai, X., & Zhang, M. (2021). Effect of refractance window drying on the physicochemical properties and microbial safety of fruits and vegetables. *Food Research International, 137*, 109634. https://doi.org/10.1016/j.foodres.2020.109634

Sablani, S. S., & Rahman, M. S. (2020). Food drying technologies: An overview and a look at the future. *Comprehensive Reviews in Food Science and Food Safety, 19*(5), 2146-2172. https://doi.org/10.1111/1541-4337.12589

Raghavi, L.M., Moses, Jeyan. & Chinnaswamy, Anandharamakrishnan. (2017). Refractance Window Drying of Foods: A Review. Journal of Food Engineering. 222. 10.1016/j.jfoodeng.2017.11.032.

* * * * * * * * *