doi:10.1017/S1431927622004391
Microsc. Microanal. 28 (Suppl 1), 2022


# Evaluation of Microstructural Changes in Parenchymal Tissues of Potato During its Convective Drying by Confocal Scanning Laser Microscopy (CLSM)

Stephany Montserrat Gutiérrez Martínez[1], Ricardo Aguilar Garay[1], Susana Dianey Gallegos-Cerda[1], Josué David Hernández-Varela[1], Benjamín Arredondo Tamayo[1], José Jorge Chanona Pérez[1]

[1.] Laboratorio de super resolución y nanoestructuras, Departamento de ingeniería bioquímica, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, Av. Wilfrido Massieu, Mexico city, Mexico.
* Corresponding author: sgutierrezm2000@alumno.ipn.mx

## Introduction

Drying is a fundamental processing and preservation technology for plant materials, processed foods and gels. Often, the main purpose of drying is to increase shelf life by reducing water activity to an acceptable level [1]. As well as ensuring product quality, such as rehydration capacity, appearance, texture, microstructure, and taste sensation. A better understanding of heat and mass transport phenomena through the interfaces of plant tissues with their environment, especially at the microscale, is a key element to improve dehydration processes and final quality of products [2]. Thus, microstructure is important in the heat and mass transfer interfacial phenomena, control processing conditions and foodstuffs quality during its drying. Therefore, the aim of this was to evaluate the correlation between drying kinetics and microstructural changes occurred in parenchymal tissues of potato during its convective drying and evaluated by means of confocal microscopy

## Materials and Methods

Fresh potatoes (*Solanum tuberosum variety alpha*) without physical damage or rotting were washed and cut into slices of 3 mm thick and 40 mm in diameter. The slices were scalding in hot water at 90 °C for 5 min, then cooling in fresh water at 4 °C for 2 min [3]. Potato slices were dried at 70 °C and 3 m/s of airflow in a laboratory dryer. Drying and thermal kinetics were carried out during 180 min. Thermographic images were acquired in real with an infrared thermometer (IR28). The moisture ratio was calculated with equation (1).

$$MR = \frac{M_t - M_e}{M_0 - M_e} \quad (1)$$

Where $M_t$ = is the moisture content at any time; $M_0$= is the moisture content at time zero; $M_e$ = is the moisture content at equilibrium time.

Microstructural analyses were performed using a confocal laser scanning microscope (LSM-880 Carl Zeiss, Germany). Fresh potato slices and under thermal treatment slices were stained using a solution (10:1) of 0.01% of calcofluor white (Fluorescent brightness, 28, F3543, Sigma-Aldrich, USA), and a 0.003% of rhodamine B (329768608, Sigma-Aldrich, USA). Samples were observed using a 10X- 20X Zeiss a-Plan Apochromat objective. A thin section of fresh potato tissue and dehydrated tissue were obtained and stained as follows, to fresh sample, tissue was immersed into an aqueous solution of rhodamine B for 18 h to stain the starch contained into potato tissue, then several washes were performed to remove the exceeding dye, subsequently, a calcofluor white solution was added drop by drop to stain cellulose and let dry during 5 min. For dehydrated potato, the same procedure was realized, however, rhodamine B and calcofluor solution were prepared in ethanol to avoid the rehydration of samples. The visualization of samples was realized using the excitation lines of 405 and 514 nm for

calcofluor white and rhodamine B, respectively [4].

## Results and discussion

The initial moisture of the slices potatoes was 77.50% ± 2.41, the moisture of the slices decreased exponentially during drying process (180 min). At the beginning (0 min), the surface temperature of the slices remains constant around 25 °C ± 0.5 (Figure 1), slices in purple and blue colors, this indicating that during this time the moisture tend to be uniform, and surface is water saturated (25 °C is temperature of water. Then, the surface temperature increasing (green and yellow color), and regions water saturated decreasing gradually, in this period moisture is mainly transferred by molecular diffusion and water transport depends strongly on food microstructure [5], [6]. This period is knows as falling drying rate period, specifically at 70 °C the equilibrium moisture (Xe) was reaching after 60 minutes (Figure 1) and surface temperature tended to be constant in green and yellow color. Thus, it is possible to say that at this time the drying process ends, and it is an interesting time for carried out the microstructural study with CLSM.

Figure 2 shows the CLSM images of potato slices, where the well-defined cells conformation stained with blue was observed in the fresh tissue (time 0 min), Figure 2a shows that cell distribution shapes and size were homogenous and isodiametric parenchymatic cell potatoes could be observed with a high content of starch granules (red color, Figure 2b), where cell and starch granules not showed damages. In contrast, after 60 minutes of drying process at 70 °C severe cellular damages were observed (Figure 2c), provoke cell shrinkage, cell wall breaking and gelatinization of starch granules [7], specifically the granules are perceived as dissolved into the cytoplasm of cells, also the cells loss its shape and cell wall has thinned (Figure 2d, see green arrows).

## Conclusions

Thermographic and CLSM images were useful to describe the drying process of parenchymal tissues of potato during its convective drying. The drying process cause severe damages in the microstructure of parenchyma cells and starch granules. More microstructural studies are required to evaluate structural changes of biological materials caused by drying process.

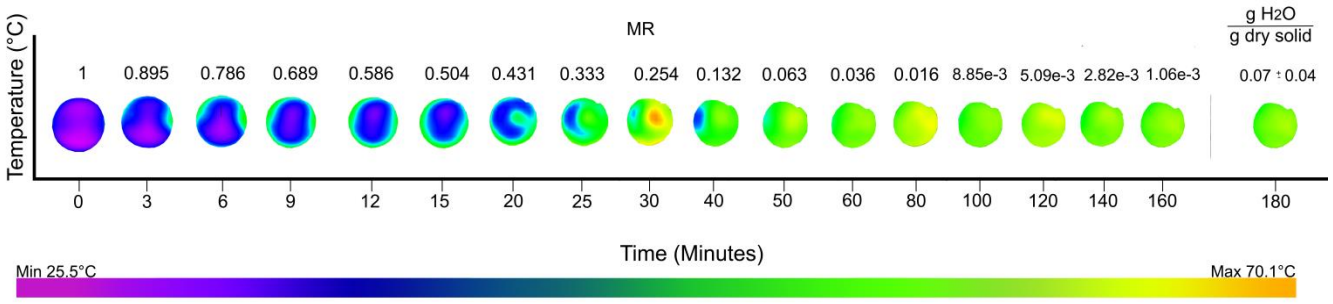


**Figure 1.** Temperature profile and moisture ratio of potato slices during drying process at 70 °C for 180 min, and at 180 min the absolute moisture is shows.

https://doi.org/10.1017/S1431927622004391 Published online by Cambridge University Press

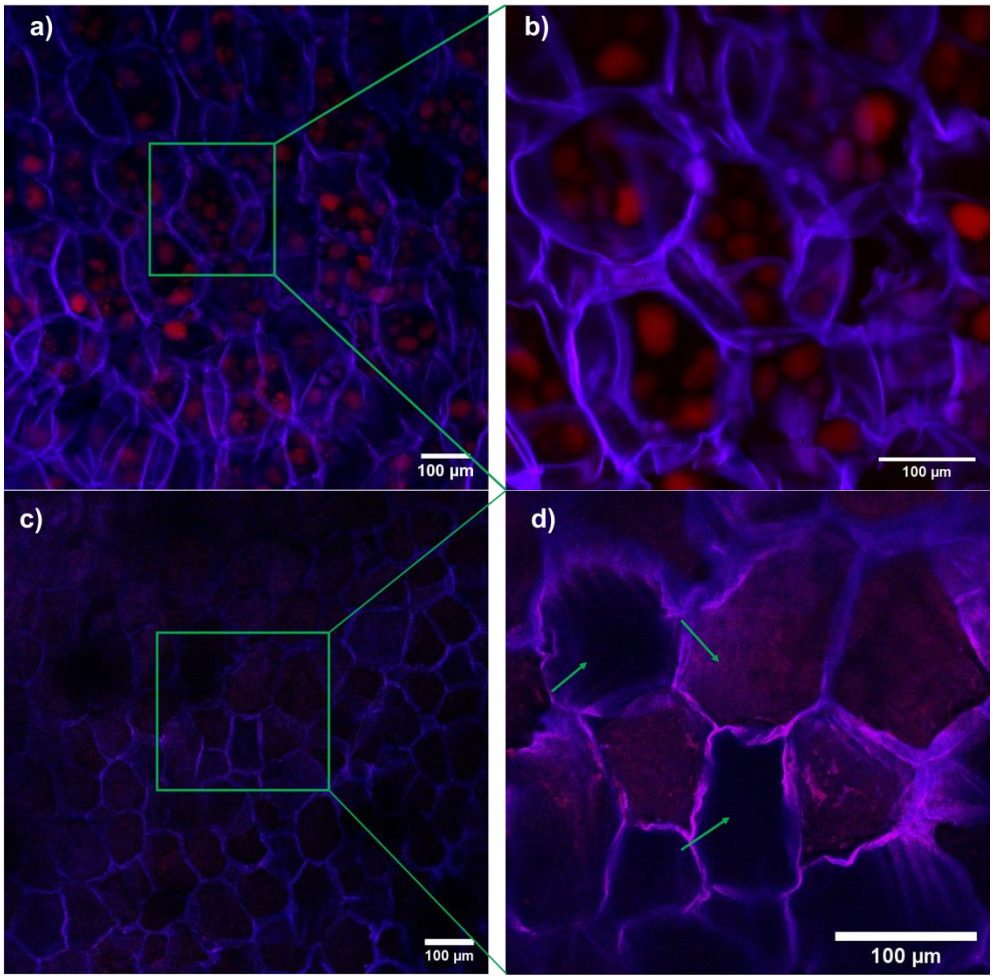


**Figure 2.** Confocal laser scanning microscopy images of potato tissue at 0 (a and b) and 60 min (c and d) of drying (70 °C and airflow 3 m/s).

References:

[1] M. H. Joardder, M.U.H. & Masud, "Causes of Food waste," in Food Preservation in Developing Countries: Challenges and solutions, C. Springer, Ed. 2019, pp. 27–55.
[2] T. K. Nguyen, M. Mondor, and C. Ratti, J. Food Eng., vol. 230, pp. 8–17, 2018, doi: 10.1016/j.jfoodeng.2018.02.017.
[3] S. Naderinezhad et al., Food Sci. Nutr., vol. 4, no. 1, pp. 110–118, 2016, doi: 10.1002/fsn3.258.
[4] J. D. Hernández-Varela et al., Food Hydrocoll., vol. 124, no. September 2021, p. 107252, 2021, doi: 10.1016/j.foodhyd.2021.107252.
[5] R. Jabeen, T. Aijaz, and K. Gul, Cogent Food Agric., vol. 1, no. 1, p. 1036485, 2015, doi: 10.1080/23311932.2015.1036485.
[6] M. Beigi, Heat Mass Transf., vol. 52, pp. 1435–1442, 2016, doi: 10.1007/s00231-015-1646-8.
[7] Z. Zhang et al., *Lwt*, vol. 125, no. March, p. 109357, 2020, doi: 10.1016/j.lwt.2020.109357.

https://doi.org/10.1017/S1431927622004391 Published online by Cambridge University Press